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Cognitive Flexibility and Spoken Discourse in Younger and Older Adults

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Cognitive Flexibility and Spoken Discourse in Younger and Older Adults

by

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Dedication

This work is dedicated to the woman who gave me life…

To my mother, Loretta Nickerson Cage, thank you for your undying support and for your unselfish love.

…and the men who make it worth living.

To my husband, Delaney Fleming, Jr., thank you for encouraging me to be all I ever dreamed I could be.

To my son, Delaney Fleming III, thank you for showing me what unconditional love is all about.

Acknowledgements

Trust in the Lord with all thine heart; and lean not unto thine own understanding. In all thy ways acknowledge Him, and He shall direct thy paths. KJV Proverbs 3:5-6

My heart is overflowing with thanksgiving and praise for God our Creator, our Provider. Although the paths He chose for me were not always easy, I trusted in Him and He never left me or failed me. He provided for me when I did not even know I needed provision. Out of His abundant Blessings, the one that I most treasure is the wonderful family He blessed me with to love me so dearly.

I want to thank my husband Delaney Fleming, Jr. and my son Delaney III “Trey” for all of their sacrifices and support. I also want to acknowledge my family and in-laws for their encouraging words and well wishes.

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Cognitive Flexibility and Spoken Discourse in Younger and Older Adults

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Spoken discourse production and the cognitive flexibility component of executive function were examined in 40 neurologically intact younger and older adults. Two spoken discourse tasks differing in complexity were administered. Resulting discourse samples were analyzed for complexity and quality. Sentential analyses included: length of t-units (mean number of morphemes); amount of embedding (number of clauses per t-unit); and percent of dependent clauses. Total words and total t-units also were tabulated. Qualitative analyses included the number of indefinite terms used in proportion to total words, percent of mazed words per total words, and percent of utterances with mazes. Verbal and nonverbal fluency tests were administered to assess cognitive flexibility. No definitive support for an age group by cognitive flexibility effect emerged. Overall, spoken discourse ability did not decrease with age. Rather, as measured by a relatively complex discourse production task, younger and older adults differed in the percent of utterances containing mazes. Cognitive flexibility, however, as measured by verbal and nonverbal fluency tasks, decreased with age. Results of this study provide preliminary

support for further exploration of the relationship between age, spoken discourse production, and cognitive flexibility, an assumed component of executive function.

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Chapter 1: Introduction and Problem

Understanding the intricacies of human aging is a complex task. The complexity of the task is compounded when trying to determine how these natural processes influence human social communication. Speech-language pathologists have a distinct interest in aging. Their interest lies in determining underlying causes of age-related changes in communication. Appreciation of the influence of normal aging processes on communicative ability provides a basis for understanding disorders of communication. Typically, speech-language pathologists treat the disordered linguistic systems of individuals with frank brain injury. However, treatment effectiveness might be increased by improving cognitive processes, if these processes make a significant contribution to spoken discourse production. Neurolinguists hypothesize that something other than poor linguistic skills contributes to disordered discourse (Brownell, Michel, Powelson, & Gardner, 1983). Poor discourse performance has been attributed to underlying deficits in attention, memory, or planning rather than linguistic deficits (Brownell et al., 1983; Patry & Nespoulous, 1990). A more complete understanding of the role of cognitive ability in spoken discourse production can be key to increased insight about aging affects on human social communication.

Decrements of spoken discourse production in normal aging have been well documented (Cooper, 1990; Glosser & Deser, 1992; Mackenzie, 2000; North, Ulatowska, Macaluso-Haynes, & Bell, 1986; Ulatowska, Hayashi, Cannito, & Fleming, 1986). Reductions in referencing ability, syntactic complexity, and macrostructural elements in older adults have been attributed to both cognitive deterioration (Glosser & Deser, 1992; North et al., 1986; Ulatowska et al., 1986) and slower information processing speed (Cooper, 1990). However, there is disagreement as to whether observed decrements were due to normal or pathological aging (e.g., dementia) (Bayles, 1982). The use of the term typically, or normally, aging generally refers to individuals who do not have a history or diagnosis of neurological injury, dementia, or psychiatric illness. Despite the disagreement about the normalcy of the observed changes, most agree that linguistic and cognitive abilities of older adults are generally poorer than those of younger adults.

Structural changes in the aging brain have been implicated in age-related decrements in cognition (Albert, Duffy, & Naeser, 1987; Cabeza, 2002; Raz, 2000). Both neuroanatomists and neurobiologists indicate that age-related alterations in brain structure are more prevalent in the frontal lobes than in other areas of the brain (Dempster, 1992; Raz, 2000; Raz et al., 1997). Raz (2000) suggested the distinction between physiological aging and pathological aging may be that deterioration of prefrontal cortex is more characteristic of normal aging, while changes in the hippocampus are more likely features of early Alzheimer's dementia. If this is true, then normally aging individuals should demonstrate cognitive decline in abilities purportedly subserved by prefrontal areas of the brain, including those processes encompassed by executive function.

Executive function refers to higher-order cognitive functions such as shifting, problem solving, and goal setting that are used in novel, conflicting, or complex tasks (Godefroy, 2003). Although there are structural changes in the brain, Cabeza (2002) provided modest support that not all older adults have reduced cognitive abilities. The author found that in some adults, rewiring might allow for the maintenance of cognitive skills across the lifespan. Those who are able to recruit other areas of the brain for compensation are less likely to show decrease in abilities. Variable ability to recruit alternate brain areas likely accounts for the variability in performance among older adults on tasks requiring higher cognitive ability. One such task is spoken discourse production.

Due to age-related structural changes in the brain, theories about functions subserved by those areas (e.g., prefrontal cortex) also exist. The frontal lobes are considered the primary area for executive function (Filley, 2000; Stuss & Alexander, 2000; Stuss & Benson, 1986; Tranel, Anderson, & Benton, 1994). In cognitive aging, the executive decline hypothesis states that there is a selective decline in executive function in normal aging (Crawford, Bryan, Luszcz, Obonsawin, & Stewart, 2000; Dempster, 1992; Parkin & Walter, 1992) rather than a general cognitive decline. The selective decline in executive function is the result of neuroanatomical and neurochemical alterations being more evident in the frontal lobes of the brain. When compared to younger adults, older adults often perform more poorly on tests of executive function (Bryan & Luszcz, 2000a; Raz, Gunning-Dixon, Head, Dupuis, & Acker, 1998). The executive decline hypothesis allows researchers to attribute age-related declines in complex tasks to a decline in executive function ability.

The executive decline hypothesis is very similar to and often used interchangeably with the frontal lobe hypothesis of aging. The frontal lobe hypothesis of aging simply states that older adults perform more poorly on measures of frontal lobe function when compared to younger adults (for review see Dempster, 1992 and West, 1996). The difference is that the frontal lobe hypothesis of aging refers to the more general cognitive abilities supported by the frontal lobes (West, 1996) such as memory and attention, not executive function specifically. Because executive function is essential in almost all cognitive tasks, variations in executive abilities serves as a plausible explanation for age-related declines in information processing ability (Raz, 2000) and in tasks that require information processing.

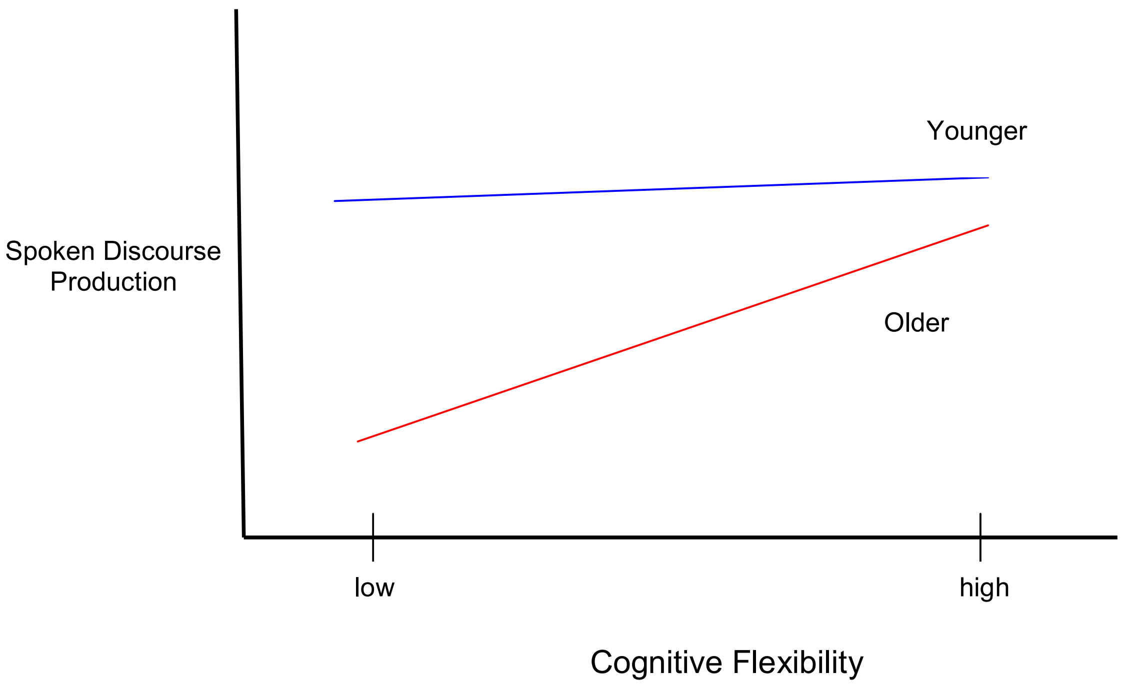
The speed of information processing hypothesis has also been implicated in age-related performance decrements seen in older adults (Bryan, Luszcz, & Crawford, 1997).

Information processing theories of executive function explain how executive function is responsible for task analysis, strategy control, and strategy monitoring in tasks that require the encoding, manipulating, storing, and retrieving of information (Borkowski & Burke, 1996). Scientists in cognitive aging believe there is a generalized slowing that occurs with increasing age affecting cognitive performance, especially on complex tasks (Salthouse, 1985). The speed of information processing hypothesis suggests that this generalized slowing would affect a complex task such as spoken discourse production. Although an individual may be able to maintain complexity in spoken discourse while reducing speech rate, there is a possibility of compromise in the amount of information processed (both input and output). Slowing can interfere with an individual's ability to complete task analysis, strategy control, and strategy monitoring efficiently. Older adults may compensate for generalized slowing by reducing the complexity of their spoken discourse.

While there are documented declines in spoken discourse production with age, no one has attributed the changes specifically to reduction in a component of executive function. Given the previously mentioned theories, documented decrements in spoken discourse production with age, and the possible role of executive function in communication, it is reasonable for one to attribute age-related decreases in discourse to performance declines in executive function or in one of its components. Therefore, the hypothesis for this study was that the relationship between age and spoken discourse production performance differs at different levels of cognitive flexibility (i.e., a specific component of executive function) because age would adversely affect spoken discourse production more for individuals with low cognitive flexibility compared to those with high cognitive flexibility. Cognitive flexibility is the component of executive function that allows divergent thinking (Bryan & Luszcz, 2000a; Demakis & Harrison, 1997; Keil

& Kaszniak, 2002) or the ability to produce different ideas (Eslinger & Grattan, 1993; Purdy, 2002). Most research has examined the main effect of age, but none has addressed the interaction between age and a specific component of executive function. Figure 1 illustrates the hypothesis for the present study.

Figure 1. Illustration of Hypothesis

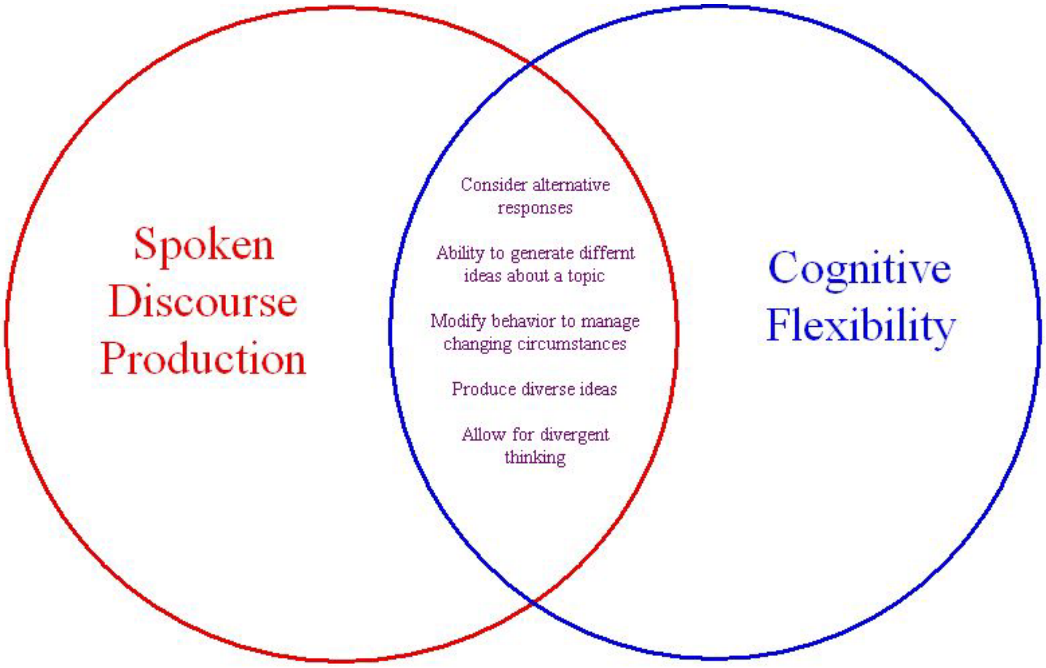


Specifically, the questions that this study addressed were: 1) Does increasing discourse complexity reveal age-related decreases in spoken discourse production? 2) Do younger and older adults differ in the cognitive flexibility component of executive function? 3) Does cognitive flexibility affect spoken discourse production? and 4) To what extent does age and cognitive flexibility influence performance on spoken discourse production tasks?

Neuropsychologists and communication scientists have alluded to the importance of executive function in communication (Glosser & Goodglass, 1990; Perry & Hodges, 1999; Purdy, 2002; Radanovic, Azambuja, Mansur, Porto, & Scaff, 2003; Ramsberger, 2000); however, researchers do not agree to what extent executive function influences language (Keil & Kaszniak, 2002). Evidence from adults with traumatic brain injury indicates executive function has a role in higher-level communication such as spoken discourse production (Coelho, 2002; Coelho, Liles, & Duffy, 1995). Conversely, little research exists on the contribution of specific components of executive function to communication ability in typically aging adults.

Although other components of executive function such as planning, shifting, or abstract reasoning, potentially affect spoken discourse, cognitive flexibility seems to capture aspects of executive function needed for divergent thinking (Bryan & Luszcz, 2000a; Demakis & Harrison, 1997; Keil & Kaszniak, 2002). Divergent thinking contributes greatly to richer, high-quality spoken discourse. The ability to produce different ideas, consider alternative responses, and modify behavior to manage changing circumstances all contribute to cognitive flexibility (Eslinger & Grattan, 1993; Purdy, 2002). An individual would have to possess divergent thinking skills flexible or accommodating enough to integrate information and produce discourse according to specified, situational constraints (e.g., topic maintenance). Figure 2 depicts the relationship between spoken discourse and cognitive flexibility.

Figure 2. Spoken Discourse Production and Cognitive Flexibility



The focus of the present study was to explore the cognitive flexibility component of executive function and to understand the contributions of cognitive flexibility to spoken discourse production. By understanding the relationship between cognitive flexibility and spoken discourse production in normally aging populations, speech-language pathologists may be able to improve treatment of communication disorders. If the hypothesis regarding the importance of cognitive flexibility to successful spoken discourse production were supported, it would provide a rationale for continued exploration of executive function and discourse. If the current study does not provide support for the hypothesis, then there is the possibility that some other component of executive function is more important to spoken discourse production.

The aims of the present research were to: 1.) identify quantitative and qualitative characteristics of younger and older adults' spoken discourse; 2.) determine if there are differences in younger and older adults' cognitive flexibility as measured by verbal and nonverbal fluency tasks; and 3.) understand the relationships between spoken discourse production and cognitive flexibility in younger and older adults.

The significance of this study lies in its potential to provide more information about spoken discourse in typically aging adults. Specifically, the study can provide an explanation for the discrepancies in current age-related spoken discourse production literature. This study also has the potential to provide more information about how older adults compare to younger adults on two distinct spoken discourse production tasks. In addition, this study may provide insight about how cognitive flexibility, a component of executive function differs in two age groups. Moreover, the current study can demonstrate cognitive flexibility's contribution to spoken discourse production ability. Finally, this study serves as an initial investigation of the relationship between spoken discourse and cognitive flexibility. If the relationship exists, then further exploration is warranted to determine how cognitive flexibility affects other variables of spoken discourse.

The following chapter will review literature pertinent to spoken discourse production and aging and executive function and aging.

Chapter 2: Review of the Literature

SPOKEN DISCOURSE PRODUCTION

Discourse is the basic unit of human social communication (R. H. Brookshire, 1997; Brownell & Joanette, 1993) and is of great interest to many disciplines from linguistics to communication sciences and disorders. For communication scientists, it is often important to study language in its naturalistic form, discourse. Due to its inherent complexity, discourse provides a unique opportunity to observe the interaction between linguistic and nonlinguistic abilities (Glosser & Deser, 1992). By investigating the discourse of typically aging adult populations and what influences successful production, communication scientists can make decisions as to what is normal communication and what is not. Appreciation of the typical linguistic characteristics of normally aging adult populations is necessary before understanding language disturbances in pathological aging such as what occurs in stroke or dementia (Cannito, Hayashi, & Ulatowska, 1988; Shadden, 1997). Understanding typical linguistic characteristics is also necessary to determine treatment approaches (Shadden, Burnette, Eikenberry, & DiBrezzo, 1991). In addition, the study of language in aging is imperative because speech-language pathologists have a role in the maintenance and enhancement of communication for older adults (American Speech-Language-Hearing Association, 1988). For assessment, spoken discourse has become the linguistic unit of observation because of its ecological validity, freedom from examiner bias, and functionality (R. H. Brookshire, 1997).

Discourse Genres

Discourse can differ in terms of content, form, and use, thereby giving rise to different discourse genres. In brain damaged and nonclinical populations, discourse genres have different cognitive and/or linguistic demands (Coelho, Liles, & Duffy, 1991;

Harris, Rogers, & Qualls, 1998; Hartley & Jensen, 1991; Ulatowska, Allard, & Chapman, 1990). There are four widely studied discourse genres: conversational, expository, narrative, and procedural discourse. In conversational discourse, partners have to interact with each other and in their interaction, they must negotiate topics, turns, and repairs. Participants in conversation exchange information in a variety of roles and situations. Researchers often evaluate parts of conversational discourse such as turn-taking, topic maintenance, requests, and breakdown repair. Expository discourse has the primary purpose to convey information and is often historical or scientific (Stine-Morrow, Miller, & Leno, 2001). Narrative discourse has the primary purpose to entertain (Ulatowska et al., 1990) and typically involves the telling or retelling of stories. Narrative discourse of the typical episodic structure has identifiable elements such as a setting, an initiating event, and a conclusion.

Of the four discourse genres, the one that is least studied is that of procedural discourse, although it is often used in assessment (Snow, Douglas, & Ponsford, 1997). The primary function of procedural discourse is to inform or instruct (Ulatowska et al., 1990), and is characterized as having steps which may either be essential or nonessential (Cannito et al., 1988). An essential step is one that allows the listener or reader to know the basic actions needed to do the task while a nonessential or optional step provides additional details or clarification (Cannito et al., 1988; Ulatowska, Doyel, Stern, Haynes, & North, 1983). The divisions of discourse genres for experiments are rather artificial because everyday conversation contains a combination of multiple genres (Snow & Douglas, 2000).

Spoken Discourse Production and Aging

Discourse literature clearly documents age-related decrements in spoken discourse production, but uncertainty lies in determining if the declines are due to variations in language processing or to cognitive deficits. If due to language processing alterations, then one would expect the dissolution of discourse in linguistic tasks. Any associated neuroanatomical or neurobiological changes would be observed primarily in the perisylvian area of the language-dominant hemisphere (Glosser & Deser, 1992). Alternatively, if age-related decrements are due to cognitive alterations that affect language processing ability, then declines should be observed in tasks requiring the integration of linguistic and nonlinguistic processes such as attention, processing speed, memory, and executive function (Glosser & Deser, 1992). Neuroanatomical and neurobiological changes would be more diffuse, and not solely confined to the perisylvian area. It is apparent that nonlinguistic cognitive processes contribute to discourse production ability (Bell et al., 2003; B. L. Brookshire, Chapman, Song, & Levin, 2000; Daneman, 1991; Hartley & Jensen, 1991). The cognitive demands of spoken discourse, coupled with decreases in cognition, should negatively affect spoken discourse performance in older adults. While there is general consensus about the influence of reduced cognitive abilities on discourse, there is little agreement about which discourse elements are most vulnerable.

In discourse literature, there is more interest in the investigation of linguistic variables. Research has produced mixed results regarding syntactic complexity and length of discourse in typically aging adults. Some researchers have reported that there are no significant declines in syntactic complexity with age (Cannito et al., 1988; Cooper, 1990; Glosser & Deser, 1992; Ulatowska & Chapman, 1991; Ulatowska et al., 1986). In a study including eighty adults between the ages of 20 and 78 years, Cooper (1990) used a picture description task to investigate complexity in terms of the number of subordinate clauses per 100 words. She found no significant effects of age. However, it is important to note that participants were given an unlimited amount of time to talk about the pictures demonstrating that older adults would impart the same amount of information as younger adults if given enough time (Cooper, 1990).

In a homogeneous sample of fifty-one women aged 27 to 92 years, Ulatowska et al. (1986) obtained two types of narrative discourse. The first, the Cat Story, was a retelling of a simple narrative using sequencing pictures (Ulatowska, North, & Macaluso-Haynes, 1981). The second, an O'Henry Story, was a retelling and response to probe questions about a complex narrative. The researchers investigated syntactic complexity in response to the Cat Story and the O'Henry Story in terms of noun phrase syntactic complexity. They found no age differences on either of the tasks.

Likewise, using an interview format to elicit discourse, Gloser and Desser (1992) found no significant differences between younger and older adults in terms of syntactic complexity. The study included 27 healthy volunteers divided into two groups. The researchers asked participants to describe their family and then a work experience. While not statistically significant, their data suggested a reduction in syntactic complexity in older adult participants, who produced fewer embedded subordinate clauses than the middle-aged participants (Glosser & Deser, 1992).

Conversely, other studies have found decreases in syntactic complexity or length with age (Kemper, 1987; Kynette & Kemper, 1986). Kynette and Kemper (1986) elicited discourse from a middle-aged group and an older group by asking the participants to tell stories about their lives, such as their first job, war experiences, or marriage. The middle-aged group used more complex structures with multiple embeddings, embedding plus coordination, and complex combinations of structures. The older group made more errors in the use of simple syntactic structures.

Mackenzie (2000) examined length of discourse in terms of efficiency of communicating content (i.e., information). Word count relative to content unit count in a picture description task was the basis for the efficiency measure. The author found that adults in the oldest group were less efficient at communicating information in discourse because the oldest group used more words per content unit during the description task. In addition, the efficiency measure demonstrated consistency over time in the normal population. Kynette & Kemper (1986) however, found that older adults tended to have smaller language-unit length with advancing age. This finding has been supported by other studies of older adults spoken discourse (Shadden, 1997).

In addition to syntactic complexity and length, there have been questions as to whether there is decline in the informational content or the number of themes present in discourse. Older adults have been found to provide less relevant information and produce fewer propositions (North et al., 1986). A proposition is an idea unit that contains one predicate and one or more arguments associated with it, and is considered the most fundamental unit of information (Ulatowska & Chapman, 1991). More specifically, North, Ulatowska, Macaluso-Haynes, & Bell (1986) found evidence indicating that older adults had reduced performance on cognitive as well as on discourse tasks. In addition to scoring lower on cognitive tests (*Block Design*, *Raven's*, *Symbol-Digit*, *Word Fluency*), older adults recalled fewer propositions and had more difficulty producing an acceptable summary or moral of narratives. Furthermore, older adults tended to produce fewer essential steps on procedural discourse tasks (North et al., 1986). In contrast to this finding, Cooper (1990) found that there was no relationship between age and the amount of information present in an oral picture description task.

Based on the aforementioned studies, there are mixed results regarding the performance of older adults on spoken discourse tasks. Why is this? One could attribute contradictory conclusions to methodological issues (Obler et al., 1994). For example, some studies used picture stimuli, while others used interviews or self-generated responses. As an alternative explanation, the disparity could be due to individual differences in participants' abilities. Ulatowska, et al. (1986) concluded that multiple factors, including physiological and cognitive decline, might account for the variability in linguistic ability of older adults. As a result, these researchers suggested that discourse tasks needed heavier cognitive loading, or increased task demands. By increasing the demands of the task, the linguistic ability of older adults would be clarified (Ulatowska et al., 1986). A generative discourse task versus a retelling or picture description task would entail greater cognitive demands, as would the use of a combination of discourse genres rather than a single genre. Heavier cognitive loading should reveal changes in linguistic ability, to the extent that decrements in higher cognitive skills, such as executive function, or one of its components, contribute to spoken discourse production.

EXECUTIVE FUNCTION

Current theories of information processing provide a sound framework for investigating the relationship between executive function and spoken discourse production. Research has shown that there is a relationship between information processing and declines in higher cognitive functions (Baltes & Lindenberger, 1997). Since executive function is essential in almost all cognitive tasks, decreases in executive function may account for observed age-related deficits in information processing (Raz, 2000). These deficits, in turn, may contribute to the dissolution of spoken discourse production in aging.

Executive Function and the Brain

Generally, the term “executive function” is used to refer to higher-order cognitive functions underlying the performance of novel, conflicting, or complex tasks (Godefroy, 2003). Neuropsychologists view executive function as a set of processes that allow an individual to sequence, change set (i.e., shifting), set goals (i.e., planning), problem solve, and sustain attention (Crawford, 1998; Phillips, 1997). Abilities such as self-regulation, flexibility, response inhibition, and organization are also included under the umbrella-term “executive function” (Eslinger, 1996). These executive processes are responsible for cognition and all behavior (Phillips, 1997) and are important in regulating other cognitive processes such as memory and attention (Wecker, Kramer, Wisniewski, Delis, & Kaplan, 2000).

Historically, executive functions have been associated with the frontal lobes of the brain (Tranel et al., 1994). Specifically, the relevant areas of the frontal lobes are: the dorsolateral prefrontal cortex (DLPFC), which has been linked to motor programming, hypothesis generation, and set shifting; the orbitofrontal cortex, which as been connected to appropriate social behavior through the maintenance of personality and comportment; and the medial orbital cortex which is related to arousal and motivation (Filley, 2000). When damage occurs to these structures, a distinctive complex set of sequelae appear, including various combinations of disinhibition, apathy, and impaired higher cognitive skills. Sequelae are aggregated and labeled “frontal lobe syndrome” or “executive dysfunction” (Filley, 2000, p. 98). The neuropsychological/frontal lobe premise supports the notion that frontal brain structures are important for emotional regulation, attentional processes, visuospatial processing, memory, and executive function (Keil & Kaszniak, 2002). The term “frontal lobe syndrome” may be misleading because executive dysfunction may be present in the absence of frontal lobe damage.

More recently, advances in neuroimaging have been instrumental in visualizing discrete regions of the brain (Collette & Van der Linden, 2002; Elliott, 2003). Not only can researchers better identify discrete regions, but they can also see them with increased clarity. Several studies have found evidence indicating that executive function tasks activate other areas in addition to frontal regions of the brain (Adcock, Constable, Gore, & Goldman-Rakic, 2000; Collette & Van der Linden, 2002; Sylvester et al., 2003). In a study investigating the neural activation of switching and response inhibition tasks, functional magnetic resonance imaging (fMRI) revealed evidence of activation in bilateral parietal cortex in addition to the left dorsolateral prefrontal cortex (DLPFC), premotor cortex, and medial frontal cortex (Sylvester et al., 2003). The use of dual-task paradigms has demonstrated that there are no specific structures devoted to a general executive system (Adcock et al., 2000). In a review of neuroimaging studies, Andrés (2003) concluded that the *Wisconsin Card Sorting Test* (WCST: Heaton, Chelune, Talley, Kay, & Curtis, 1993), one of the most commonly used tests to measure executive function (Keil & Kaszniak, 2002), was not specifically sensitive to frontal lesions. The studies Andrés (2003) reviewed confirmed that prefrontal, parietal, temporal, hippocampal cortices, and basal ganglia are activated during performance of the test. The premise that executive functions exist in one, unitary structure (i.e., the frontal lobes) may be false (Andrés, 2003). Researchers' judgment of executive dysfunction may be limited when they restrict themselves to a unitary structural view. Such a conservative view may exclude those without frontal lobe lesions, especially normally aging adults who may only have age-related deterioration of prefrontal or other brain structures (Raz, 2000). Further advancement of imaging technology may contribute increased refinement of theories of executive function.

Theories of Executive Function

Modern study of executive function stems from the work of Luria (1973) and contemporary researchers often base their theories and models on his work. Luria (1973) described the way in which frontal lesions affected human behavior. Lesions in the frontal lobes of his patients resulted in an inability to think abstractly, and disrupted organized, goal-directed behavior. He believed the anterior frontal lobes were significant in behavior and therefore proposed a theory of brain behavior relationship. He asserted that the anterior frontal lobes developed responses based on the input from other brain systems. To Luria, the anterior frontal lobes served as an administrator of sorts. Information would come in from other brain areas and the anterior frontal lobes would integrate the information and then form a response. The frontal lobes had several administrative or executive functions assigned to the region, including planning, analysis, and programs of behavior. Luria suggested that the prefrontal lobes helped to manage behavioral regulation through speech. Patients with prefrontal lobe damage often loose the "regulatory power of language" (Stuss & Benson, 1986, p. 178) and while they may correctly verbalize a task, they may not perform the task accurately (Luria, 1973). Disconnect between verbalization and action allows one to see the disruption of goal-directed behavior. Based on Luria's general ideas, other frontal lobe theorists formulated their ideas about executive function.

Norman and Shallice (1986) developed a model of executive function based on information processing. Theoretically, the prefrontal cortex supports their Supervisory Attentional System (SAS). During novel situations, this system is responsible for the selection of nonhabitual responses and the inhibition of habitual or automatic responses. The hierarchically arranged model has a lower level that allows the operation of schema-based "automatic" programs of action (Norman & Shallice, 1986, pp. 2-3). The higher level, which can intervene and change or stop automatic responses, supervises the lower level, which allows for more cognitive flexibility. The primary function of the system is planning, but the system also coordinates and allocates attentional resources. The SAS has been compared to and is quite similar to the central executive component of working memory (Wilson, Evans, Emslie, Alderman, & Burgess, 1998).

Baddeley and Hitch’s model of working memory (1986) contains the central executive, which is in some ways similar to the SAS developed by Norman and Shallice (1986). Working memory involves the temporary storage and manipulation of information needed for various complex cognitive activities (Baddeley, 1986, 2003). Working memory has three components, one of which is the central executive. The responsibility of the central executive is to control and regulate the two slave-systems, the phonological loop and the visuospatial sketchpad. The phonological loop is a subsystem for the temporary storage and manipulation of verbal and acoustic stimuli, while the visuospatial sketchpad is a parallel visual subsystem for storage and manipulation of visual stimuli. The central executive is thought to be primarily housed in the frontal lobes of the brain and is responsible for attentional control of working memory and may be broken up into many executive processes (Baddeley, 1996, 1998). Individual variability in working memory may be explained by differences in these executive processes (Daneman & Carpenter, 1980). That is, various working memory capacities may be more dependent on the efficiency of the executive processes (i.e., central executive) more so than the phonological loop or the visuospatial sketchpad. In addition, working memory has been implicated as having a significant influence on language processing (Baddeley, 2003); especially in discourse production (Bell et al., 2003; Daneman, 1991) and disorders of any of the components of working memory (including the central executive) can impact language processing.

Unlike SAS and working memory models, which primarily describe executive function in terms of attention, Lezak (1995) described executive function as having four primary components: 1) volition; 2) planning; 3) purposive, goal-directed action; and 4) effective performance. Volition refers to the mental capacity needed for intentional behavior. This includes the ability to formulate goals, initiate activity, and to be aware of oneself in relation to one’s surroundings. Planning includes the ability to conceive of alternatives, sustain attention, and look ahead. Purposive action is the programming of sequences of complex behavior in an orderly and integrated manner. Individuals need purposive action to move from a plan to a productive activity. Effective performance refers to the ability to monitor, self-correct, and regulate behavior. Lezak’s model opened the door for ways to better operationalize executive function in an effort to better assess and understand this complex entity.

The Validity and Assessment of Executive Function

One of the challenges inherent to the study of executive function is how researchers assess it (Keil & Kaszniak, 2002). The instruments used to assess executive function have led to the difficulty in operationalizing the constructs of executive function (Bryan & Luszcz, 2000a) which in turn has been cited as an obstacle for researchers (Filley, 2000). Initially, tests of executive function were developed based on known frontal lobe injury deficits, not on the theoretical construct of executive function. Consequently, there has been a violation of construct validity (Phillips, 1997) or questions of whether executive function tests really assess the underlying theoretical construct of “pure” executive function (Phillips, 1997, p. 208). In addition, the situation is further complicated by problems with content validity. What may be a test of executive function to one researcher may be a test of attention or visuospatial processing to another.

This lack of agreement about current assessment instruments contribute to the complexity of assessing executive function.

Another assessment issue is one of specificity (Bryan & Luszcz, 2000a; Keil & Kaszniak, 2002; Murray & Ramage, 2000). Specificity is the ability of a test instrument to specify or discriminate behaviors. It is the ability of a test instrument to classify non-disordered persons as non-disordered. Therefore, when a person does not have disordered executive function skills, a test of executive function will classify that person as not being disordered. For an example, a valid test of executive function will be able to differentiate executive function deficits from other deficits. Thus, constructing executive function measures that are specific enough has the tendency to be a challenging task.

In addition to specificity, another issue emerges when attempting to assess executive function, the issue of sensitivity (Bryan & Luszcz, 2000a; Keil & Kaszniak, 2002; Murray & Ramage, 2000). Sensitivity is how well a test instrument detects a condition in the population. It is important that measures are sensitive enough to detect subtle changes in ability (Bryan & Luszcz, 2000a; Keil & Kaszniak, 2002; Murray & Ramage, 2000) especially when assessing normally aging adults. Sensitivity is clearly an issue that researchers have to address in understanding executive function.

One way to address the issues of specificity and sensitivity is to be clear about the operationalization of executive function. Several researchers have found evidence that there is a fractionation of executive function (Allain, Etcharry-Bouyx, & Le Gall, 2001; Amieva, Phillips, & Della Sala, 2003; Baddeley, 2002; Della Sala, Baddeley, Papagno, & Spinnler, 1995; Hedden & Yoon, 2006; Miyake et al., 2000; Shallice, 2002; Sylvester et al., 2003) and they support the view of executive function including several components. This view indicates that the prefrontal cortex supports different types of executive processes, rather than one, unitary function. In order to address issues of specificity and sensitivity, it may prove more productive to assess the components of executive function instead of executive function as a whole (Keil & Kaszniak, 2002; Stuss & Alexander, 2000; Wecker et al., 2000). Components of executive function could be differentially affected or differentially contribute to other tasks. In addition, examining the components of executive function can improve the operationalization of executive function.

In an attempt to better operationalize executive function, Keil and Kaszniak (2002) divided the construct of executive function into four domains. These domains include the following: 1) planning, scheduling, strategy use, and rule adherence; 2) generation, fluency, and initiation; 3) shifting and suppression; and 4) concept formation and abstract reasoning. The authors supported the notion of investigating each of the specific domains rather than trying to examine executive function as a whole. By determining the appropriate assessments for each of these domains, the possibility of getting closer to what researchers are trying to measure becomes more attainable (Keil & Kaszniak, 2002).

In addition to dividing the construct of executive function into domains, Keil and Kaszniak (2002) also identified several possible assessments in each of the domains they set forth. In the first domain, the constructs were planning, scheduling, strategy use, and rule adherence. The assessments include those that test, ". . . creation of subgoals, temporal sequencing, strategy generation and application, using environmental feedback to guide behaviour, and self-monitoring" (p. 306). Two of the most widely used assessments to evaluate this domain are the *Tower of London* (TOL: Shallice, 1982) and the *Tower of Hanoi* (TOH). Each test requires the transfer of rings from a starting position to a goal position with a limited number of moves. The TOL consists of three rings of varying colors. The number of moves taken and length of time taken to complete the task determines the score. The TOH consists of disks that vary in size and there is a stacking rule based on size. Scoring here also depends on the number of moves and on how long it takes to complete the task. Additional assessments for this domain also exist (see Keil & Kaszniak for summary).

The next domain includes the constructs of shifting and suppression. Assessments in this domain include those that, ". . . require shifting between tasks (i.e., set) and inhibition of external or internal/overlearned responses" (p. 306). Assessments for this domain include the *Stroop Test* (Stroop, 1935) and the *Trail Making Test B* (Reitan, 1992). According to Keil & Kaszniak (2002), a suppression score comes from the subtraction of word meaning speed from color-word reading speed on the *Stroop Test* (Stroop, 1935). In color reading speed, the examinee must ignore the phonological stimulation of each word and say what color ink the word is printed. In the *Trail Making Test B* (Reitan, 1992), the task is to connect letters and numbers in an alternating way as quickly as possible. The score consists of completion time and the number of errors.

Another domain identified by Keil and Kaszniak (2002) includes the constructs of concept formation and abstract reasoning. Testing in this domain includes, ". . . tests that require formation of concepts and conceptualisation of abstract relationships" (p. 306). The *Wisconsin Card Sorting Test* (WCST: Heaton et al., 1993) is useful for assessing concept formation and abstract reasoning (Keil & Kaszniak, 2002). Examiners can also use the WCST to test a patient's ability to shift and maintain set, and the ability to use feedback. According to Keil and Kaszniak (2002), the WCST is one of the most widely used tests in neuropsychology to assess executive function. The WCST requires the patient to sort cards according to a set of rules using feedback from the examiner. The sorting principle shifts without warning after a certain number of correct sorts. The number of categories achieved and proportion of perseverative errors determines the score. An additional test for this domain is *Raven's Coloured Progressive Matrices*

(RCPM: Raven, 1947, 1995). The RCPM uses colored visual pattern matching and analogy problems. The examinee has to conceptualize the primarily spatial relationships within the design.

The final domain includes the constructs of generation, fluency, and initiation should include, ". . . tests that require generation of concepts and compliance with environmental constraints, and measure lack of monitoring, i.e., through perseverative errors" (Keil & Kaszniak, 2002, p. 306). Fluency tasks are thought to assess cognitive flexibility or divergent thinking (Demakis & Harrison, 1997). Several verbal and nonverbal tasks would be appropriate for this domain. Verbal tasks include different variations of word fluency. One of the most commonly used tests of word fluency is the *Controlled Oral Word Association Test* (COWAT: Benton, 1968), often referred to as the FAS test. The COWAT requires participants to generate words according to an initial letter. Another test of word fluency is *Excluded Letter Fluency* (Bryan et al., 1997). The number of words participants can generate in two 60-s trials that do not contain a specified letter assesses excluded letter fluency. Other word fluency tasks include semantic category fluency and verb fluency. It is important to note that verbal fluency tasks are only appropriate to assess executive function when the patient is not aphasic or does not have another generalized brain disturbance such as dementia that may interfere with language functions (Lezak, 1995; Phillips, 1997; Stuss & Benson, 1986). A nonverbal test of fluency may be more appropriate for these individuals.

Several nonverbal tests of fluency also exist. One assessment for this domain is the *Graphic Pattern Generation*. In the *Graphic Pattern Generation* task, patients have to generate novel response patterns to a stimulus of five dots. Scoring is based on perseverations and rule-breaking (Keil & Kaszniak, 2002). An additional assessment for this domain is the *Sequence Generation Test* (SGT). In the *Sequence Generation Test*, examinees generate random sequences of three numbers using a computer keypad. Scoring is based on perseverations and perseveration distance, and the SGT may assess response to feedback. Another similar nonverbal fluency task is the *Ruff Figural Fluency Test* (RFFT: Ruff, Light, & Evans, 1987). The RFFT provides information about nonverbal ability on flexibility and the ability to shift cognitive set, planning strategies, and executive ability to coordinate this process. The RFFT requires participants to produce as many different designs as possible within a set time limit of 60 seconds by connecting the dots in different patterns.

Normal Aging and Executive Function

Deficits in executive function can influence daily life and independence in adults (Helm-Estabrooks, 2000; Ramsberger, 2000). Evidence indicates that executive function may have a mediational role in age-related cognitive decline (Salthouse, Atkinson, & Berish, 2003). Several studies have found that age negatively affects executive function (Daigneault, Braun, & Whitaker, 1992; Ettenhofer, Hambrick, & Abeles, 2006; Libon et al., 1994; Raz et al., 1998; Ylvisaker & Szekeres, 1989). Although the study of executive functioning in neurologically impaired populations is often of greater priority, the study of alterations in executive function due to aging also deserves attention.

In an investigation of effects of normal aging on prefrontal measures of perseveration, Daigneault, Braun, & Whitaker (1992) administered a battery of assessments that included the *Self-Ordered Pointing Task* (Petrides & Milner, 1982), the *Wisconsin Card Sorting Test* (Heaton, 1981), *Porteus Mazes* (Porteus, 1965), the *Controlled Oral Word Association Test* (Benton & Hamsher, 1983) using the letter P, F, and L, *Design Fluency* (Jones-Gotman & Milner, 1977), and *Stroop Test* (Stroop, 1935). Results indicated that older adults had significant decline on one of the three timed tasks

(*Stroop Test*) and on all of the three untimed tasks (SOPT, WCST, and *Porteus Mazes*). The researchers concluded that the differences were due to deterioration of the prefrontal cortex associated with normal aging.

Similarly, Libon et al. (1994) assessed adults using timed and untimed executive function measures. The researchers administered the *Trail Making Test*, the *Stroop Test*, COWAT, category fluency, WCST, and the Manual Postures (MP) subtest from the *Goldberg Executive Control Battery* (Goldberg, 1986). The researchers examined the relationship between executive function and visuospatial ability in normally aging older adults. They evaluated thirty-seven participants aged 64 to 94 years. They found that there was a significant age effect for the *Trail Making Test*, the WCST, and the MP. The older participants, age 75 and older, had deficits in problem solving, mental flexibility, and the ability to maintain and shift mental set, which are all consistent with executive function decline.

Ettenhofer, Hambrick, & Abeles (2006) examined 118 normally aging adults aged 54 years to 87 years on five measures of executive function. The study used the WCST, *Stroop Test*, *Trail Making Test*, and two measures of verbal fluency (letter fluency and category fluency) to examine reliability and stability of commonly used executive function measures. Their analyses demonstrated strong relationships between age and executive function suggesting that the older adults in their investigation had poorer executive function performance with increased age (Ettenhofer et al., 2006). In addition, their results also indicated that executive function was a relatively stable construct in normally aging older adults.

Research regarding the use of word fluency tasks to assess executive function ability in aging is abundant. Word fluency measures have been found to be sensitive to age-related differences (Ettenhofer et al., 2006; Fisk & Sharp, 2004; Parkin & Lawrence, 1994; Parkin & Walter, 1992). Bryan, Luszcz, & Crawford (1997) found small age-related declines in verbal fluency ability in older adults, especially in excluded letter fluency. They obtained similar findings in a later study in which younger adults performed better on the *Excluded Letter Fluency* task than older adults (Bryan & Luszcz, 2000b). Bryan & Luszcz (2000a) suggested from their review that the usefulness of word fluency tests to assess executive decline in older adults is still not well established. They believed that the FAS (i.e., COWAT) may not be sensitive enough to detect subtle changes with age and that preserved verbal ability of older adults enhances their performance on this task. They suggested the use of other fluency tasks such as semantic fluency, excluded letter fluency, or design fluency due to the more novel nature of these tasks (Bryan & Luszcz, 2000a).

Cognitive decline in aging parallels physiological aging of the brain (Albert et al., 1987; Raz, 2000). That is, there is often a selective decline and preservation of skills. Selective decline or preservation could be of any cognitive process, but most likely, selective decline is in the area of executive function as is the executive decline hypothesis (Crawford et al., 2000; Dempster, 1992; Parkin & Walter, 1992). Some or all of the specific skills of executive function may be differentially affected. The current study hypothesizes that selective executive function decline is in the area of cognitive flexibility, and that decline in cognitive flexibility contributes to age-related differences in spoken discourse production. Cognitive flexibility, as measured by verbal and nonverbal fluency tasks, has been shown to activate the frontal lobes (Demakis & Harrison, 1997; Eslinger & Grattan, 1993; Keil & Kaszniak, 2002; Sylvester et al., 2003; Tranel et al., 1994) which are important for receiving input and integrating responses to dynamic or changing stimuli (Luria, 1973) and appear to be the most affected by age-related structural changes according to aging-brain hypotheses (Dempster, 1992; Fuster, 1997; Raz, 2000; Raz et al., 1997). When participating in a novel task such as spoken discourse production, individuals need cognitive flexibility (i.e., a component of executive function) in order to change and shape their behavior in response to the dynamic nature of the task (Norman & Shallice, 1986).

The following chapter will describe and discuss the research methodology selected to respond to the problem.

Chapter 3: Method

PARTICIPANTS

Forty neurologically intact adults, ages 18-89 years old (mean age = 50.35, SD = 21.89) participated in the current study. Several participant selection criteria were met including: (a) English speaking; (b) negative for neurological injury, dementia, or psychiatric illness as determined by self-report on a health questionnaire; (c) at least 12 years of high school or equivalent; (d) at least a 25 out of 30 points on the *Mini-Mental State Exam* (MMSE: Folstein, Folstein, & McHugh, 1975); (e) vision and hearing sufficient for the tasks as observed by interaction with the examiner.

A convenience sample of volunteer participants was recruited from Austin, Texas and surrounding communities through: 1) flyers and by word-of-mouth; 2) the Communication in Adults Research Group (CARG) at The University of Texas at Austin; and 3) local independent-living facilities and retirement communities. No attempt was made during participant recruitment to include or exclude participants based on other population characteristics; therefore, the sample was not well balanced in regard to gender, ethnicity, or educational levels. The study offered participants compensation for their participation in the form of a $10 dollar gift card and receipt of incidental information about normal aging, gained during their participation. Some participants viewed their participation as an act of volunteerism and decided to forego compensation. Because this study investigated age group differences, participants were not randomly assigned to groups. Table 1 summarizes the relevant demographic data of the participants including age, gender, ethnicity, and years of education.

Table 1. Participant demographic data

Group			Min.	Max	Mean	Std. Deviation
Younger (n=14)	**Age in years**		18.00	38.00	26.57	7.57
	Gender	Male (n=2)				
		Female (n=12)				
	Years of Education		13.00	19.00	15.79	2.52
	Ethnicity	Caucasian (n=7)				
		African American (n=5)				
		Hispanic (n=1)				
		Asian (n=1)				
Older (n=26)	**Age in years**		40.00	89.00	63.15	15.18
	Gender	Male (n=7)				
		Female (n=19)				
	Years of Education		12.00	20.00	15.15	2.37
	Ethnicity	Caucasian (n=17)				
		African American (n=5)				
		Hispanic (n=4)				
		Asian (n=0)				
All (N=40)	**Age in years**		18.00	89.00	50.35	21.89
	Gender	Male (n=9)				
		Female (n=31)				
	Years of Education		12.00	20.00	15.38	2.41
	Ethnicity	Caucasian (n=24)				
		African American (n=10)				
		Hispanic (n=5)				
		Asian (n=1)				

INSTRUMENTATION

The protocol for the present study consisted of screening, abilities tests, and experimental tasks. The *Mini-Mental Status Examination* (MMSE: Folstein et al., 1975) served as a screening test. The MMSE, a brief quantitative measure of cognitive status in adults, was administered to screen for alterations in cognitive status. The MMSE assesses cognitive status in the domains of orientation, registration, attention and calculation, recall, and language (naming, repetition, 3-stage command, reading, writing, and copy design). Examiners gave each participant one point for each question/task completed correctly for a total of 30 points. A score of 24 points or less out of 30 points is indicative of cognitive status alterations. Participants below the cut-off of 25 points were ineligible to participate in this study. No participants were excluded based on their performance on the MMSE.

The Logical Memory subtest of the *Wechsler Memory Scale*-III (Wechsler, 1997) served as an abilities test and as a means to more fully characterize the participants in this study. The Logical Memory subtest is a measure of memory based upon the number of story units recalled. Examiners administered the subtest to assess memory for connected speech. The participants were administered only the Story B portion of the subtest. The Logical Memory subtest required the participant to listen to a short story read aloud by the examiner. The participant had to retell the story immediately using as many of the same words as possible. After a filled delay of about 30 minutes, the participant retold the story again. The participants were audiotape-recorded to ensure accurate, off-line scoring. The participants' story retellings were scored for both story and thematic units.

Speed of information processing was assessed using *The Digit Symbol Substitution Test* (DSST: Wechsler, 1981), a measure of perceptual speed. Participants filled in blank squares with symbols paired to the digits displayed above the squares, according to a table of paired digits and symbols. Participants had 90 seconds to graphically produce as many symbols substitutions as possible. The number of correctly completed substitutions was recorded.

Experimental Tasks

Each participant was assessed in terms of spoken discourse production and cognitive flexibility. Following the suggestion of Ulatowska et al. (1986), the first discourse task had a relatively high cognitive load and will be referred to as a simulated complex discourse elicitation task (CDET: Communication in Adults Research Group *CARG*, 2005). The complex discourse elicitation task protocol was used to elicit a language sample from each participant. The task required participants to pretend that they were planning a trip to New York City. Examiners asked participants to describe in detail activities associated with preparing for this trip. This generative discourse production task had the potential to contain elements of both narrative and procedural discourse, thus contributing to its relatively greater complexity. Procedural tasks are presumed to be more complex than picture description tasks or story-retell tasks (Shadden et al., 1991). Examiners also administered a second discourse task that was assumed less complex than the first discourse task. The examiners asked each participant to recount his or her best vacation. This task was thought to be less complex because it involved less planning than the complex discourse elicitation task and it contained only those elements inherent to a narrative task. In addition, it was a conceptualization of the participant's own personal experience, rather than one that the participant had to generate. Both discourse tasks are thought to be more difficult than a retell task with either an auditory or a picture stimulus. In addition, each task is more likely to require some degree of executive function because they both require organization, sequencing, as well as low task constraint (Shadden et al., 1991).

Examiners assessed cognitive flexibility using verbal and nonverbal fluency tasks. Fluency tasks are appropriate for assessing the cognitive flexibility component of executive function because cognitive flexibility encompasses the notion of fluency. Fluency requires divergent thought and production hence, the generation of diverse or different responses (Eslinger & Grattan, 1993). In addition, fluency tasks were suitable because they required the generation of appropriate responses under a given set of conditions (Tranel et al., 1994) similar to what the participants were required to do for the spoken discourse production tasks. The verbal fluency tasks were the *Controlled Oral Word Association Test* (COWAT: Benton, 1968) an initial letter fluency task, often referred to as the FAS test and the *Excluded Letter Fluency* task (Bryan et al., 1997). The COWAT required participants to produce words according to a targeted initial letter. Participants had to complete three 60-second trials. In the first trial participants produced as many words as they could that began with the letter F, and in the second trial the letter A, and in the third trial, the letter S. Excluded letter fluency was assessed by the number of words participants could generate in two 60-second trials that did not contain a specified letter. In the first trial, participants produced as many words as they could that did not contain the letter E, and in the second trial, they produced as many words as they could that did not contain the letter A. Not only did the individual have to generate appropriate responses, they also had to inhibit responses that contained excluded letters, which increased the demands of the task. Since the two tasks appeared to have different cognitive demands, they were subsequently analyzed individually. Acceptable words for both tasks could not be proper nouns or alternate forms of the same words (e.g., walk, then walking or walked), or perseverations. The nonverbal fluency task used to assess cognitive flexibility was the *Ruff Figural Fluency Test* (RFFT: Ruff et al., 1987). The RFFT provided information about the ability to shift cognitive set, to plan strategies, and about the executive ability to coordinate this process. The RFFT required participants to produce as many different designs as possible within a time limit of 60 seconds. The participants had to create different figures by connecting five dots arranged in different patterns. Five different patterns were completed.

DATA COLLECTION AND OTHER PROCEDURES

The author, undergraduate, and graduate students working on the CARG project collected all data. To strengthen the internal validity and reliability of the study, test administration procedures were standardized by examiners reading and administering assessments from a prepared script. All participants were tested individually, and were administered an identical battery of language and psychological tests. In addition, general identifying information, such as chronological age and educational status was also collected. Health information was based on self-report using a health questionnaire. Testing order was counter-balanced to reduce order effects. Testing required one 90-minute session. Participants that previously participated in the CARG project were called and asked to return to complete a half hour testing session required to finish testing that was not done initially (i.e., verbal and nonverbal fluency tasks, DSST, and the second discourse task). Language samples and Logical Memory performance were audio recorded for later analysis to ensure accurate transcription and scoring. All discourse was transcribed verbatim. Undergraduate students working on the CARG project performed transcription. Reliability of the transcription was assessed for inter-judge reliability. The number of words disputed by the two judges, divided by the total words mutually correctly identified in the transcripts, multiplied by 100. The author randomly selected and re-transcribed 20% of the transcriptions. Inter-judge agreement was greater than 99% (inter-judge disagreement <1%). Resolutions of differences in transcription were reached through consensus by both raters.

Discourse Analysis Procedures

After the samples were transcribed verbatim and equated for length (first five minutes), both the complex discourse elicitation task (trip to New York) and the less complex discourse task (best vacation) were analyzed for complexity and quality. Each sample was segmented into t-units. A t-unit is one independent clause and all dependent clauses that modify it (Cannito et al., 1988). Based on a modified version of the analyses used by Ulatowska et al. (1983), the discourse samples were analyzed using sentential analyses. Sentential analyses included measures of quantity and language complexity: length of t-units as measured by mean number of morphemes; amount of embedding expressed in number of clauses per t-unit; and the percentage of total clauses that are dependent clauses. Additional quantitative analysis included the total number of words and the total number of t-units. Transcripts were analyzed using *Systematic Analysis of Language Transcripts* (SALT: Miller & Inglesias, 2006).

Qualitative analysis was obtained through three measures. The first was the number of indefinite terms used in proportion to total number of words. An indefinite term or nonspecific noun or pronoun is a general term and does not specify a certain class of person or objects. The use of nonspecific nouns and pronouns can contribute to empty speech (Nicholas, Obler, Albert, & Helm-Estabrooks, 1985) and therefore diminish the quality of discourse. The second measure of quality was derived from examining maze production. Mazes provided information about word and utterance formulation difficulties (Miller & Inglesias, 2006). Difficulty with formulation can reduce the clarity of the discourse, thereby affecting the quality. Mazes were defined as false starts, repetitions, reformulations, and filled pauses. Mazes were not counted in the utterance analysis, which excluded them from quantitative measures (e.g., total number of words, length of t-unit, etc.). The percent mazed words were of total words and percent of utterances with mazes were measured.

A third measure of quality, completed only on the complex discourse elicitation task, was through the thematic coding of information. The coding was scored according to the CARG (2005) protocol. Based on schema theory, individuals use schema or background information in communicative interactions in order to interpret information (Beers, 1987). Schema theory allows individuals to have a set idea, or schema of what is involved in preparing for a trip. The use of this background knowledge would help make an individual's spoken discourse sample more complete or typical if he or she included more elements from the schema of taking a trip. The absence or presence schema information or "core elements" gave insight about the typicality and richness of the discourse sample. Qualitative scoring of the discourse sample was based on a three-point scale. The core element category received a score of 0 if the discourse sample has no mention of the category. The score of 1 was given if there was some mention of the category that was very brief, usually only one sentence. The score of 2 was given for detailed mention of a category consisting of multiple references. The score for each category was summed to determine the Core Element score. Scoring was completed by consensus of two or more (usually four) certified speech-language pathologists who were members of the CARG group. Table 2 lists all scored core elements and provides examples of each.

Table 2. Core Element examples

Core Element	Examples
Temporal	decide what day/time need to go
Transportation/Ticket	flight tickets, rental car, travel agents
Work/School/Family	call my boss, arrange for substitute teacher
Money/Cost	figure out how much it will cost, go to the bank, credit card
Clothing/Packing	check weather, pack warm clothing, shoes, personal care
Lodging	arrange hotel, stay with friends
Medication/Health	took prescription medication
Securing/House	lock the doors, take care of cats
Activities	empire state building, statue of liberty, Broadway shows
Food	restaurants, China Town, New York style food
People	meet with friends, family or old acquaintances
Identification	driver's license, credit card, passport
Local Cost/money	withdraw cash for local expenses, credit cards

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Reliability of discourse analysis was assessed for inter- and intra-judge reliability. Twenty percent of the discourse samples were randomly chosen and re-scored by the author. Ten percent of the discourse samples were also randomly chosen for scoring by a second judge familiar with the scoring procedures. Scores from the samples were then compared with their original scores to determine the reliability of the analytical procedures. Intra-judge reliability was >98% for the re-scored samples and the inter-judge reliability was >95% for the re-scored samples.

In summary, the derived data for each participant included demographic information (i.e., age, years of education, ethnicity, and gender) and scores for screening and abilities tests (MMSE, Logical Memory Total, and DSST). In addition, experimental data for each participant included scores for cognitive flexibility tasks (COWAT, *Excluded Letter Fluency*, and RFFT) and spoken discourse production variables (total number of words, total number of t-units, length of t-unit, amount of embedding, percent of dependent clauses, proportion of indefinite terms, percent of mazed words, percent of utterances with mazes, and Core Element Total). The following chapter will detail the statistical analyses and results of the present study.

Chapter 4: Results

The purpose of this study was to explore the cognitive flexibility component of executive function and to understand the contributions of cognitive flexibility to spoken discourse production performance in normal younger and older adults. This study addressed these purposes by: 1) identifying quantitative and qualitative characteristics of younger and older adults' spoken discourse; 2) determining if there were differences in younger and older adults' cognitive flexibility as measured by verbal and nonverbal fluency tasks; and 3) examining the relationships between spoken discourse and cognitive flexibility in younger and older adults. The questions that this investigation proposed to answer were: 1) Does increasing discourse complexity reveal age-related decreases in spoken discourse production? 2) Do younger and older adults differ in the cognitive flexibility component of executive function? 3) Does cognitive flexibility affect spoken discourse production? and 4) To what extent does age and cognitive flexibility influence performance on spoken discourse production tasks?

Results will be presented in the following order: the relationship between spoken discourse production and age, cognitive flexibility and age, spoken discourse production and cognitive flexibility findings, and finally analyses of the contribution of both age and cognitive flexibility to spoken discourse production.

THE RELATIONSHIP BETWEEN SPOKEN DISCOURSE PRODUCTION AND AGE

Descriptive statistics (means, ranges, and standard deviations) are reported in Table 3 and Table 4 for all demographic, spoken discourse, and cognitive flexibility measures analyzed in this study.

Table 3. Summary of demographic, discourse, & cognitive flexibility data

		N	Mean	Range	Std. Dev.
AGE IN YEARS			50.35	18-89	21.89
YEARS OF EDUCATION			15.38	12-20	2.41
MINI-MENTAL STATE EXAM		40	29.25	27-30	.78
LOGICAL MEMORY TOTAL		40	34.93	10-58	10.23
DIGIT SYMBOL SUBSTITUTION		38*	55.55	25-95	16.74
COWAT		40	41.98	18-62	11.96
EXCLUDED LETTER FLUENCY		40	28.55	9-48	10.57
RUFF FIGURAL FLUENCY TEST		40	87.90	30-130	24.40
+CDET	Total Number of Words	40	290.05	98-781	153.74
	Total Number of t-units	40	28.58	10-68	13.57
	Length of t-unit	40	11.77	7.61-22.10	2.83
	Amount of Embedding	40	1.32	1-1.70	.17
	% Dependent Clauses	40	23.49	0-45	10.37
	Prop. of Indefinite Terms	40	.05	.02-.12	.02
	% Mazed Words	40	8.40	1-20	4.86
	% Utterances with Mazes	40	46.20	.82-95.24	22.40
	Core Element Total	40	12.78	6-20	3.71
BEST	Total Number of Words	38*	455.68	75-867	206.52
VACATION	Total Number of t-units	38	44.89	10-93	19.87
	Length of t-unit	38	11.03	7.54-16.23	1.98
	Amount of Embedding	38	1.21	1-1.65	.12
	% Dependent Clauses	38	17.16	0-39.51	7.75
	Prop. of Indefinite Terms	38	.04	.02-.07	.01
	% Mazed Words	38	8.82	0-20	4.52
	% Utterances with Mazes	38	44.98	2.50-88	19.68

* Two young adult participants did not return to complete additional testing and do not have scores for the DSST or Best Vacation samples +CDET: complex discourse elicitation task

Table 4. Summary of demographic and cognitive flexibility by group

		N	Mean	Range	Std. Dev.
AGE IN YEARS	Younger	14	26.57	18-38	7.57
	Older	26	63.15	40-89	15.18
YEARS OF EDUCATION	Younger	14	15.79	13-19	2.52
	Older	26	15.15	12-20	2.38
MINI-MENTAL STATE	Younger	14	29.50	29-30	.52
EXAM	Older	26	29.12	27-30	.86
LOGICAL MEMORY	Younger	14	39.57	29-58	8.41
TOTAL	Older	26	32.42	10-53	10.39
DIGIT SYMBOL	Younger	12*	70	59-95	10.37
SUBSTITUTION	Older	26	48.88	25-79	14.87
COWAT	Younger	14	46.14	34-60	9.12
	Older	26	39.73	18-62	12.84
EXCLUDED LETTER	Younger	14	34.64	22-48	7.99
FLUENCY	Older	26	25.27	9-47	10.45
RUFF FIGURAL	Younger	14	105.71	66-130	16.49
FLUENCY TEST	Older	26	78.31	30-123	22.67

* Two young adult participants did not return to complete additional testing and do not have scores for the DSST or Best Vacation samples

Discourse Type

The first question that this study investigated was: Does increasing discourse complexity help reveal age-related decreases in spoken discourse production? To answer this question, participants provided two spoken discourse samples: a recall of their best vacation, which was a relatively less complex spoken discourse production task, and the complex discourse elicitation task, a relatively more complex spoken discourse task. Participants provided both discourse samples in order to uncover whether tasks with higher cognitive demands reveal age-related decrements in performance. All experimental spoken discourse variables were assessed for normal distribution through the use of a modified Kolmogrov-Smirnov test known as a Lilliefors (Green & Salkind, 2005) in the SPSS statistical software package (SPSS, 2005). All discourse variables with the exception of three were normally distributed within a 95% confidence interval and were entered into the parametric analyses. The discourse variables of complex discourse elicitation task total number of words, complex discourse elicitation task total number of t-units, and Core Element score were not normally distributed. Therefore, those three variables were not entered into any parametric analyses and were treated separately using nonparametric procedures.

To determine if the two spoken discourse samples were different in terms of the measured discourse variables, a paired samples t-test was completed using the normally distributed variables. To control for Type I errors across the multiple comparisons, a more rigorous significance level was adopted ($p<.008$) based on a Bonferroni correction for six multiple comparisons for a .05 alpha level (.05/6). The two discourse samples were statistically different in terms of the amount of embedding ($t(37) = 3.35$, $p = .002$ with a d value of 1.15); percent dependent clauses ($t(37) = 3.30$, $p = .002$ with a d value of 1.14); and proportion of indefinite terms ($t(37) = 4.29$, $p <.001$ with a d value of 1.48). In the behavioral sciences, the d statistic can be used to calculate effect sizes with d values of .2, .5, and .8 regardless of sign. The d value is interpreted conventionally as small, medium, and large effect sizes, respectively (Green & Salkind, 2005). The previous effect sizes can all be interpreted as large. Table 5 summarizes the results of the paired samples t-test. Effect sizes are also presented.

Table 5. Summary of paired samples t-tests for two discourse samples

				Paired Differences					
		Mean	Std. Dev.	Mean	Std. Dev.	Std. Err. Mean	t	df	Sig. (2-tailed)
Length of t-unit	+CDET	11.85	2.88	.82	2.77	.45	1.83	37	.075
	BV	11.03	1.98						
Amount of Embedding	CDET	1.33	.18	.11	.20	.03	L 3.35	37	.002*
	BV	1.21	.12						
% Dependent Clauses	CDET	23. 70	10.60	6.54	12.20	1.98	L 3.30	37	002*
	BV	17.16	7.75						
Prop. of Indefinite Terms	CDET	.05	.02	.02	.03	.00	L 4.29	37	<.001*
	BV	.04	.01						
% Mazed Words	CDET	8.32	4.78	-.50	3.73	.60	-.83	37	.413
	BV	8.82	4.52						
% Utterances with Mazes	CDET	47.67	21.63	2.68	16.17	2.62	1.02	37	.313
	BV	44.98	19.68						

Note. +CDET = complex discourse elicitation task; BV = Best Vacation. L = Large Effect Size d > +/- .8.
*Statistically significant at p <.008.

The two non-normally distributed discourse variables for the complex discourse elicitation task total number of words and total number of t-units, which were measured in both discourse samples, were entered into a Wilcoxon Signed Ranks Test to determine if there was statistical difference between the two samples on those variables. Both of the variables were statistically significant with less complex task (best vacation) having more words and more t-units. Tables 6 and 7 details the results.

Table 6. Summary of Wilcoxon Signed Ranks test ranks

		N	Mean Rank	Sum of Ranks
Total number of words Best Vacation - Total number of words CDET	Negative Ranks	7(a)	10.29	72.00
	Positive Ranks	31(b)	21.58	669.00
	Ties	0(c)		
	Total	38		
Total number of t-units Best Vacation - Total number of t-units CDET	Negative Ranks	6(d)	10.58	63.50
	Positive Ranks	32(e)	21.17	677.50
	Ties	0(f)		
	Total	38		

a Total number of words Best Vacation < Total number of words CDET
b Total number of words Best Vacation > Total number of words CDET
c Total number of words Best Vacation = Total number of words CDET
d Total number of t-units Best Vacation < Total number of t-units CDET
e Total number of t-units Best Vacation > Total number of t-units CDET
f Total number of t-units Best Vacation = Total number of t-units CDET

Table 7. Summary of Wilcoxon Signed Ranks test statistics

	Total number of words Best Vacation - Total number of words CDET*	Total number of t-units Best Vacation - Total number of t-units CDET*
Z	-4.329(a)	-4.453(a)
Asymp. Sig. (2-tailed)	.000	.000

a Based on negative ranks.*Statistically significant at the p <.001 level

To determine if the best vacation task (less complex discourse) was sensitive enough to detect age-related differences on any of the measured discourse variables, an independent-samples t-test was conducted. To control for Type I errors across the multiple comparisons, a more rigorous significance level was adopted (p<.006) based on a Bonferroni correction for eight multiple comparisons for a .05 alpha level (.05/8). Of the eight variables, only one, the percent of utterances with mazes, did not have equal variances according to the Levene's Test for Equality of Variances; therefore, the "equal variances not assumed" t-value was used. None of the eight variables for the best vacation task by age group was statistically significant. The t-test values are summarized in Table 8.

Table 8. Summary of t-tests for best vacation samples

		Mean	Std. Dev.	Mean Diff.	Std. Err. Diff.	t	df	Sig. (2-tailed)
Total number of Words	Younger	530.75	224.74	109.71	70.74	1.55	36	.130
	Older	421.04	192.22					
Total # of t-units	Younger	52.42	24.15	10.99	6.79	1.62	36	.114
	Older	41.42	16.96					
Length of t-unit	Younger	11.08	2.60	.07	.70	.10	36	.918
	Older	11.01	1.48					
Amount of Embedding	Younger	1.24	.16	.03	.04	.78	36	.442
	Older	1.20	.10					
% Dependent Clauses	Younger	18.12	9.18	1.40	2.73	.51	36	.610
	Older	16.72	7.16					
Prop. of Indefinite Terms	Younger	.03	.01	-.01	.00	-1.14	36	.264
	Older	.04	.01					
% Mazed Words	Younger	6.83	3.30	-2.90	1.52	-1.90	36	.065
	Older	9.73	4.76					
% Utterances with Mazes+	Younger	36.92	12.42	-11.79	5.53	-2.13	33.87	.086
	Older	48.71	21.44					

+Equal variances not assumed due to significant Levene's Test for Equality of Variances

Although not statistically significant, younger adults had more words and more t-units than older adults. Younger adults also had longer t-units, more embedding, and percent of dependent clauses. Older adults used more indefinite terms, mazed words, and had more utterances with mazes.

To determine if the complex discourse elicitation task was sensitive enough to detect age-related differences on any of the measured discourse variables, an independent samples t-test was conducted for the normally distributed discourse variables. Of the six discourse variables computed, one, the proportion of indefinite terms, did not have equal variances according to the Levene's Test for Equality of Variances; therefore, the "equal variances not assumed" t-value was used. To control for Type I errors across the multiple comparisons, a more rigorous significance level was adopted ($p<.008$) based on a Bonferroni correction for six multiple comparisons for a .05 alpha level (.05/6). None of the six discourse variables for the complex discourse elicitation task was statistically significant based on the .008 alpha level. The t-test values are summarized in Table 9.

Table 9. Summary of t-tests for complex discourse elicitation task samples

		Mean	Std. Dev.	Mean Diff.	Std. Err. Diff.	t	df	Sig. (2-tailed)
Length of t-unit	Younger	12.10	3.46	.50	.95	.53	38	.597
	Older	11.59	2.49					
Amount of Embedding	Younger	1.32	.18	.01	.06	.11	38	.913
	Older	1.32	.17					
% Dependent Clauses	Younger	24.36	9.44	1.33	3.48	.38	38	.703
	Older	23.02	11.00					
Prop. of Indefinite Terms+	Younger	.06	.03	.00	.01	.59	17.22	.561
	Older	.05	.02					
% Mazed Words	Younger	6.64	4.48	-2.70	1.57	-1.72	38	.094
	Older	9.35	4.87					
% Utterances with Mazes	Younger	36.02	17.51	-15.66	7.08	-2.21	38	.033
	Older	51.68	23.12					

+Equal variances not assumed due to significant Levene's Test for Equality of Variances.

As with the best vacation sample, although not statistically significant, younger adults had longer t-units and a greater percentage of dependent clauses. Older adults had a greater percentage of mazed words and percentage of utterances with mazes.

The three non-normally distributed discourse variables of complex discourse elicitation task total number of words, complex discourse elicitation task total number of t-units, and the Core Element score were entered into a Mann-Whitney *U* test to determine if there was statistical difference between the younger and older groups. None of the three variables was statistically significant. Table 10 details the results.

Table 10. Mann-Whitney *U* Test for non-normally distributed variables

	Total number of words +CDET	Total number of t-units CDET	Core Element score
Mann-Whitney *U*	158.000	146.000	155.500
Z	-.681	-1.022	-.756
Significance	.510	.318	.457

+CDET: complex discourse elicitation task

THE NATURE OF THE RELATIONSHIP BETWEEN COGNITIVE FLEXIBILITY AND AGE

The second question that this study addressed was: Do younger and older adults differ in the cognitive flexibility component of executive function? To investigate the relationship between cognitive flexibility measures and age, Pearson product-moment correlation coefficients were computed between the three fluency measures and age. To control for Type I errors across the six correlations computed, a more rigorous significance level was adopted (p<.008) based on a Bonferroni correction for six multiple comparisons for a .05 alpha level (.05/6). Effect sizes are also presented. Age significantly correlated with the COWAT, the *Excluded Letter Fluency*, and the RFFT. As expected, each of the cognitive flexibility measures were correlated to each other. Correlation coefficients are summarized in Table 11.

Table 11. Correlation matrix: Age and cognitive flexibility

	Age	*Controlled Word Association Test* (COWAT)	*Excluded Letter Fluency*
Controlled Oral Word Association Test (COWAT)	[M] -.49 (.001)*		
Excluded Letter Fluency	[L] -.66 (<.001)*	[L] .73 (<.001)*	
RFFT	[L] -.72 (<.001)*	[L] .60 (<.001)*	[L] .68 (<.001)*

Note. [M] = Medium Effect Size r = +/- .3-.49, [L] = Large Effect Size r > +/- .5, (p-value), * = Significant Correlation of p<.008.

Age group differences in cognitive flexibility were computed using independent samples t-test to determine if younger and older adults performed differently on the tasks. To control for Type I errors across the multiple comparisons, an alpha level of .017 was adopted based on a Bonferroni correction for three multiple comparisons for a .05 alpha level (.05/3). Younger adults scored significantly higher on the *Excluded Letter Fluency* test, $t(38) = 2.92$, $p = .006$ with a d value of .97 and on the RFFT, $t(38) = 3.98$, $p = .001$ with a d value of 1.32. Table 12 summarizes the findings.

Table 12. Summary of t-tests for cognitive flexibility measures

		Mean	Std. Dev.	Mean Diff.	Std. Err. Diff.	t	df	Sig. (2-tailed)	Effect Size
Controlled Oral Word Association Test (COWAT)	Younger	46.14	9.12	6.41	3.88	1.65	38	.107	.55
	Older	39.73	12.84						
Excluded Letter Fluency	Younger	34.64	7.99	9.37	3.21	2.92	38	.006*	[L] .97
	Older	25.27	10.45						
RFFT	Younger	105.71	16.49	27.41	6.88	3.98	38	<.001*	[L]1.32
	Older	78.31	22.67						

Note. [L] = Large Effect Size d > +/- .8. *Statistically significant at p <.017.

COGNITIVE FLEXIBILITY AND SPOKEN DISCOURSE PRODUCTION

The next question that this study asked was: Does cognitive flexibility affect spoken discourse production? To examine the association among measures of cognitive flexibility and spoken discourse production, Pearson product-moment correlation coefficients were computed using normally distributed spoken discourse measures. To control for Type I errors across the 42 correlations computed, a more rigorous significance level was adopted ($p < .001$) based on a Bonferroni correction for 42 multiple comparisons for a .05 alpha level (.05/42). Effect sizes are also presented. Table 13 details the results.

Table 13. Correlation matrix: Cognitive flexibility & discourse

		Controlled Word Association Test (COWAT)	*Excluded Letter Fluency*	RFFT
+CDET	Length of t-unit	30 (.059)	.15 (.342)	.27 (.096)
	Amount of Embedding	.32 (.046)	.14 (.400)	.19 (.233)
	% Dependent Clauses	.33 (.035)	.15 (.355)	.25 (.115)
	Prop. of Indefinite Terms	-.20 (.219)	.03 (.834)	.09 (.586)
	% Mazed Words	-.13 (.432)	-.08 (.647)	-.24 (.145)
	% Utterances with Mazes	.06 (.711)	.09 (.595)	-.16 (.311)
Best Vacation	Total Number of Words	L .53 (.001)*	.39 (.014)	.43 (.007)
	Total Number of t-units	.49 (.002)	.34 (.036)	.31 (.060)
	Length of t-unit	.16 (.348)	.15 (.383)	.29 (.074)
	Amount of Embedding	.17 (.305)	.18 (.269)	.29 (.083)
	% Dependent Clauses	.19 (.244)	.18 (.282)	.30 (.069)
	Prop. of Indefinite Terms	-.16 (.327)	-.18 (.278)	-.23 (.161)
	% Mazed Words	-.35 (.032)	-.27 (.108)	-.41 (.010)
	% Utterances with Mazes	-.19 (.251)	-.17 (.316)	-.26 (.120)

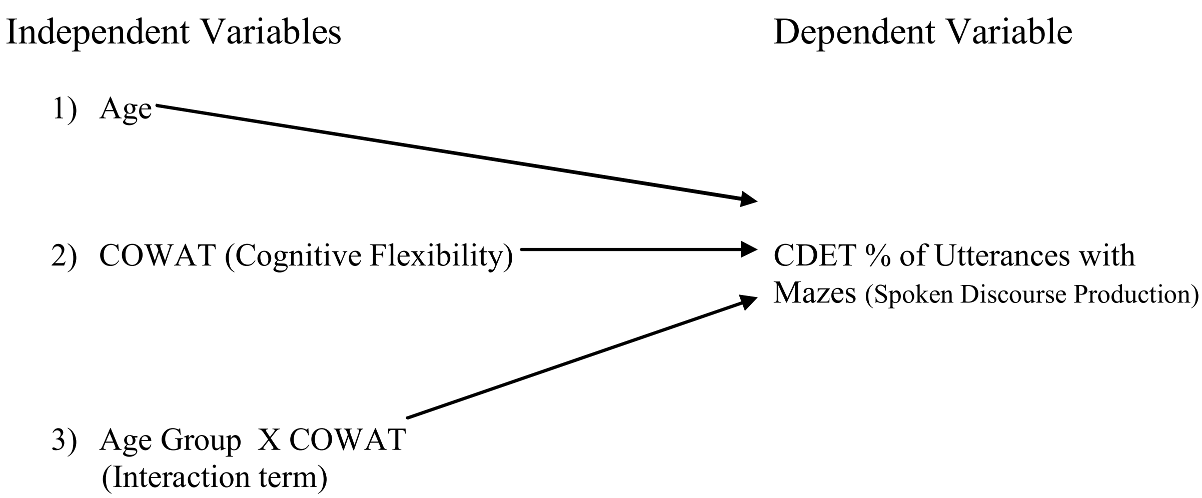
Note. L = Large Effect Size $r > +/- .5$, (p-value), * = Significant Correlation of $p<.001$. +CDET: complex discourse elicitation task

Only one of the spoken discourse production variable (best vacation total number of words) was significantly correlated to a measure of cognitive flexibility (COWAT) with a correlation of $r(38) = .53$, $p = .001$ and with a large effect size. Table 13 depicts the correlation coefficients. Correlation coefficients between the three non-normally distributed spoken discourse variables (complex discourse elicitation task total number of words, complex discourse elicitation task total number of t-units, and Core Element score) and the cognitive flexibility measures were computed using Spearman rank order correlations. Only one correlation coefficient was found to be of notable effect size. The Core Element score was positively correlated to the COWAT ($r(38) = .33$, $p = .037$).

AGE, COGNITIVE FLEXIBILITY, AND SPOKEN DISCOURSE PRODUCTION

The final question that this study investigated was: To what extent does age and cognitive flexibility influence performance on spoken discourse production tasks? To determine how the relationship between age and spoken discourse production performance differs at different levels of cognitive flexibility, a moderation model was attempted. Moderation would allow for the examination of the statistical interaction between the two independent variables of age and cognitive flexibility in predicting the dependent variable spoken discourse production (Jose, 2004). While another statistical procedure such as MANOVA could have been used, moderation was preferable because the independent variables of age and cognitive flexibility were continuous rather than categorical (Jose, 2004). To determine if the precondition for a moderation model was met, a multiple regression analysis was computed to investigate interactions between the variables. The variables of interest for the moderation model were age (independent variable), COWAT (cognitive flexibility; independent variable), and complex discourse elicitation task percent of utterances with mazes (dependent variable). The COWAT was chosen because it was the cognitive flexibility measure more highly correlated to spoken discourse production variables and was correlated with age. The complex discourse elicitation task percent of utterances with mazes variable was chosen because based on previous procedures, it was the variable that differed most between younger and older adults. First, multiple regression was used to test if the independent variables were significant predictors of complex discourse elicitation task percent of utterances with mazes. Figure 3 lists the order of the variables.

Figure 3. Order of variables for Multiple Regression for Moderation model



The main effect of Age was entered first, the main effect of COWAT (cognitive flexibility) was entered second, and the interaction term of Age X COWAT was entered third. The interaction term was created by multiplying the two main effects together. In SPSS, complex discourse elicitation task percent of utterances with mazes was entered as the dependent variable. Table 14 lists the results for the coefficients.

Table 14. Multiple Regression coefficients

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	42.594	9.073		4.694	.000
	Age	.072	.166	.070	.432	.668
2	(Constant)	29.675	21.443		1.384	.175
	Age	.134	.191	.131	.700	.488
	Controlled Word Association Test (COWAT)	.233	.350	.124	.666	.510
3	(Constant)	43.845	43.750		1.002	.323
	Age	-.117	.700	-.114	-.167	.868
	Controlled Word Association Test (COWAT)	-.113	.993	-.060	-.114	.910
	Age X COWAT	.007	.018	.232	.373	.711

a Dependent Variable: Complex Discourse Elicitation Task Percent of Utterances with Mazes

Because statistical significance of all predictors, a precondition for the use of a moderation model, was not met, further moderation analyses were not completed.

To further assess the relationship between age and spoken discourse production performance at different levels of cognitive flexibility, a MANOVA was computed. MANOVA allowed for the examination of the statistical interaction between the two independent variables of age and cognitive flexibility and how they influence a dependent variable (spoken discourse production). Since MANOVA is better suited for categorical data, the COWAT was transformed into a categorical variable using its median score of 41.50. Again, the COWAT was used due to the correlations it had with the spoken discourse production variables. Individuals scoring below 41.50 were assigned to the low cognitive flexibility group and those scoring above 41.50 were assigned to the high cognitive flexibility group. Age group was entered as a categorical variable for age. A rigorous significance level of $p < .008$ was used to control for Type I error due to the six normally distributed complex discourse elicitation task spoken discourse dependent variables entered. The overall results of the MANOVA were not significant for any main effects or for interactions. Table 15 summarizes the results.

Table 15. MANOVA results

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.999	3462.392(a)	6.000	31.000	.000	.999
	Wilks' Lambda	.001	3462.392(a)	6.000	31.000	.000	.999
	Hotelling's Trace	670.140	3462.392(a)	6.000	31.000	.000	.999
	Roy's Largest Root	670.140	3462.392(a)	6.000	31.000	.000	.999
group	Pillai's Trace	.318	2.408(a)	6.000	31.000	.050	.318
	Wilks' Lambda	.682	2.408(a)	6.000	31.000	.050	.318
	Hotelling's Trace	.466	2.408(a)	6.000	31.000	.050	.318
	Roy's Largest Root	.466	2.408(a)	6.000	31.000	.050	.318
Cognitive Flexibility Level (COWAT)	Pillai's Trace	.229	1.535(a)	6.000	31.000	.200	.229
	Wilks' Lambda	.771	1.535(a)	6.000	31.000	.200	.229
	Hotelling's Trace	.297	1.535(a)	6.000	31.000	.200	.229
	Roy's Largest Root	.297	1.535(a)	6.000	31.000	.200	.229
group * Cog. Flex Level	Pillai's Trace	.087	.490(a)	6.000	31.000	.811	.087
	Wilks' Lambda	.913	.490(a)	6.000	31.000	.811	.087
	Hotelling's Trace	.095	.490(a)	6.000	31.000	.811	.087
	Roy's Largest Root	.095	.490(a)	6.000	31.000	.811	.087

a Exact statistic

The following chapter will contain discussion of the findings of the present studying including implications and future direction.

Chapter 5: Discussion

Results of this study provide preliminary support for investigating the relationship between age, spoken discourse production, and cognitive flexibility, an assumed component of executive function. Although there was no definitive support for an age group by cognitive flexibility effect, the investigation did generate evidence to support further exploration of these relationships. Further exploration is important in order to determine whether a broader range of cognitive flexibility measures or other components of executive function influence spoken discourse production. The influence of age on spoken discourse production and measures of executive function are comparable with each other, as they seem to change in parallel as people age. It seems reasonable to assume that the same aging processes influencing spoken discourse production would also influence executive function or vice versa. The dynamics of the relationship are yet to be discovered.

In this study, the use of a relatively complex spoken discourse production task confirmed the need for a more cognitively demanding task to demonstrate age-related decline in spoken discourse production. Findings from the current study indicate that the relatively less complex spoken discourse task, best vacation, did not sufficiently tax the cognitive resources of older adults enough to reveal age-related declines. Perhaps a broader range of discourse tasks, calibrated according to cognitive loading, would reveal the point at which, the cognitive load exceeds the cognitive resources of older adults. Determining a critical threshold may contribute to a better understanding of the relationship between cognitive flexibility and spoken discourse production.

Although findings did not support the hypothesized relationship among age, cognitive flexibility, and spoken discourse production, findings in the current study indicate that cognitive flexibility influences quantitative and qualitative aspects of spoken discourse production depending on the nature of the discourse task. Older adults, even with similar education levels to younger adults, are not able to perform comparably on tasks of cognitive flexibility.

THE RELATIONSHIP BETWEEN SPOKEN DISCOURSE PRODUCTION AND AGE

The first question that this study sought to answer was: Does increasing discourse complexity reveal age-related decreases in spoken discourse production? Recall that each participant produced two spoken discourse samples. The complex discourse elicitation task, presumed to have relatively higher cognitive demands, required participants to generate spoken discourse about plans for a trip to New York. The second spoken discourse task, a recall of their best vacation, was relatively less complex. The two tasks differed significantly in terms of syntactic complexity. On the complex discourse elicitation task, participants had more embedding, percent of clauses that were dependent, and proportion of indefinite terms. The complex discourse elicitation task appeared predisposed for the use of more complex syntactical constructions. In addition, on the relatively less complex discourse tasks, best vacation, participants produced more words and more t-units. The tendency for participants to be more fluent on the best vacation task reconfirms that the task was less cognitively demanding for participants. The propensity for participants to use more complex syntactical structures in the complex discourse task appears to confirm that the task was more complex than the relatively less complex best vacation task. The question then became whether or not if the two tasks differed in sensitivity.

There was no significant mean difference between younger and older adults on the eight variables from the best vacation discourse task. Based on this finding, the assumption that there is no significant age decline in syntactic complexity is supported (Cooper, 1990; Glosser & Deser, 1992; Ulatowska et al., 1986). On the best vacation task, it is important to note that although not statistically significant, younger adults tended to have more words, more t-units, longer t-units, and more complex syntactic structures (i.e., more embedding and higher percent of dependent clauses) than older adults. Older adults had more indefinite terms, a higher percentage of mazed words, and more utterances with mazes. Of importance, the percent of mazed words came close to reaching statistical significance at $t(36) = -1.90$, $p = .065$. An alternate view demonstrates that the performance of the older adults on the best vacation task follows the trends observed by some researchers (Kemper, 1987; Kynette & Kemper, 1986). Perhaps it is because a relatively less complex task such as recall of a personal experience (i.e., autobiographical memory), may not be sensitive enough to detect age-related decrements is spoken discourse production. The best vacation task required only the recall of an autobiographical event rather than the generation of information related to a hypothetical event. Autobiographical memory is robust in typically aging older adults (Butler, 1963) and has been previously implicated in optimal performance of adults on discourse tasks (Ulatowska et al., 2001). The best vacation task required the retelling of a story that probably had told repeatedly; therefore, the retelling of a best vacation was more likely well rehearsed. Strategic rehearsal has been shown to facilitate recall (Bryan, Luszcz, & Pointer, 1999; Harris & Qualls, 2000). This may explain why older adults performed similarly to younger adults on the best vacation task. Using a task that does not rely solely on the recall of autobiographical information may be expected to be more cognitively demanding, thereby, sensitive enough to detect age-related alterations of spoken discourse.

The more complex discourse task appeared to be a more cognitively demanding. The task was generative in nature, and had the potential to contain elements of both narrative and procedural discourse. Results revealed that the percent of utterances with mazes was statistically significant by group. Older adults had more difficulty with word and utterance formulation than younger adults. Difficulty with formulation reduced the clarity of the discourse, thereby affecting the quality. Speculatively, it is most likely not the number of mazed words that a participant uses that affects the quality of the spoken discourse; but the number of times that an utterance is interrupted by a maze. While the finding of one spoken discourse variable differentiating groups is important, it is highly interesting that more discourse variables did not distinguish age groups. The lack of other variables being statistically significant supports the notion that in normally aging adults, there is no change in spoken discourse performance (Cannito et al., 1988; Cooper, 1990; Glosser & Deser, 1992; Ulatowska & Chapman, 1991; Ulatowska et al., 1986), especially in terms of complexity. The older adults in this study performed similarly to younger adults on measures of discourse length, complexity, and other measures of discourse quality such as proportion of indefinite terms, percent of mazed words, and the Core Element score. The similar performance supports the sensitivity of the complex discourse elicitation task in detecting subtle age-related differences.

The finding that the best vacation task was not sensitive to any age-related differences while the complex discourse elicitation task demonstrated some sensitivity to age-related differences, supports Ulatowska, Hayashi, Cannito & Fleming (1986) in that tasks with higher cognitive demands are needed to reveal linguistic changes in older adults. In the current study, combining genres, using self-generated tasks, and utilizing an abstract event were an attempt to increase the cognitive demands of the spoken discourse task. Even with higher cognitive demands, older adults still performed quite similarly to younger adults. This confirms one of two views. The first view posits that normally aging adults do not experience decreases in spoken discourse ability with age. If this were true, then decrements in spoken discourse with age would be an indicator of pathological aging rather than normal aging. The second view presupposes that the complex discourse elicitation task is still not cognitively taxing enough to delineate age-related decreases in spoken discourse production.

THE NATURE OF THE RELATIONSHIP BETWEEN COGNITIVE FLEXIBILITY AND AGE

The next question that this study addressed was: Do younger and older adults differ in the cognitive flexibility component of executive function? Even with a more rigorous significance level ($p < .008$), age was significantly negatively correlated with the COWAT, *Excluded Letter Fluency*, and the RFFT with medium and large effect sizes. This suggests that there is a strong relationship between age and cognitive flexibility as measured by these tasks of fluency, which supports the findings of several other studies (Bryan & Luszcz, 2000b; Bryan et al., 1997; Ettenhofer et al., 2006; Fisk & Sharp, 2004; Parkin & Lawrence, 1994; Parkin & Walter, 1992) in that older adults perform poorer on tasks of executive function. The task that was the most strongly negatively correlated to age was RFFT. This result is due in part to the nonlinguistic nature of the task, novelty of the test (Bryan & Luszcz, 2000a), and older adults not being able to draw on their preserved verbal ability to enhance their performance. While there is some disagreement as to whether the COWAT and the *Excluded Letter Fluency* task are assessments of verbal knowledge or executive function, all three of the cognitive flexibility measures used in the current study appear to be tapping into the same construct.

Each of the cognitive flexibility measures strongly positively correlated to each other suggesting that the three measures have sound convergent validity. In other words, each of the tasks appears to be measuring the same construct. Unsurprisingly, the two verbal measures of fluency demonstrated the strongest relationship because they both required verbal responses. The RFFT was most strongly correlated to the *Excluded Letter Fluency* task, possibly due to the more novel nature of the two tasks.

Group differences in cognitive flexibility were investigated. Younger adults scored significantly higher on the *Excluded Letter Fluency* test and on the RFFT. They also scored higher on the COWAT, but not significantly compared to older adults. Bryan & Luszcz (2000a) reported similar findings in that the COWAT does not seem to be sensitive enough to detect age-related changes in normal adults. The older adults were able to use their preserved verbal ability to enhance their performance on the COWAT. In addition, they did not have the demand of inhibiting the production of words excluding certain letters as in the more novel *Excluded Letter Fluency* test. The COWAT was suited for the use of phonemic strategies, while the same strategies were more difficult to employ in the *Excluded Letter Fluency* task. An explanation as to why older adults performed so differently from younger adults on the cognitive flexibility warrants further discussion.

Age-related decrement is the most logical explanation of differences in younger and older adults in these tasks of cognitive flexibility. Educational differences cannot explain discrepancies because the two groups did not differ in terms of years of education ($t(38) = .772$, $p = .437$). The groups did not differ in perceptual abilities per se because each of the participants demonstrated vision and hearing ability sufficient to complete the tasks. In addition it should be noted that as expected, the two groups differed significantly in terms of perceptual speed on the DSST, $t(36) = 4.43$, $p = <.001$. Perceptual speed was not statistically controlled in this investigation because deficits in executive function are thought to contribute to age-related decreases in information processing ability and to decrements in tasks that require information processing (Raz, 2000). Executive function is responsible for the encoding, manipulating, and retrieving of information, which is the essence of information processing (Borkowski & Burke, 1996). Although the DSST is not an executive task, it does require executive function ability and statistically controlling for it would have concealed differences in cognitive flexibility.

COGNITIVE FLEXIBILITY AND SPOKEN DISCOURSE PRODUCTION

The third question that this study investigated was: Does cognitive flexibility affect spoken discourse production? Although only one correlation was statistically significant due to a stringent alpha level of $p < .001$, there were several nonsignificant but medium effect size correlations (see Table 10). The overall finding of only one significant correlation between spoken discourse performance (best vacation total number of words) and cognitive flexibility (COWAT) could have several explanations. First, the lack of significant correlations could be reflective of the cognitive demand of the selected discourse tasks. Those discourse tasks may not have been demanding enough to have to recruit higher-level resources such as executive function. Of equal possibility is that the discourse variables measured in the two discourse tasks may not be those directly related to cognitive flexibility. Cognitive flexibility may be more important for discourse information such as noun/pronoun ratios or semantic information such as type/token ratios. There is also the possibility that cognitive flexibility may not be the component of executive function that is responsible for spoken discourse production. Other components of executive function such as planning, shifting, or abstract reasoning may be more important for spoken discourse production. The current study focused on cognitive flexibility because of the observed relationship between the necessary resources for rich spoken discourse production and cognitive flexibility (see Figure 2). Despite the small number of statistically significant correlations between cognitive flexibility and spoken discourse production, several interesting findings deserve further exploration.

The significant positive correlation between best vacation total number of words and the COWAT, demonstrates the close relationship between fluency on a spoken discourse variable and a verbal cognitive flexibility task. A similar effect was demonstrated between the COWAT and best vacation total number of t-units. Perhaps the less complex nature of the best vacation task and the linguistic nature of the less demanding COWAT fostered the relationship. In addition, other nonsignificant positive correlations of medium effect size were seen between other quantitative variables on the best vacation task and the other cognitive flexibility tasks (see Table 10) but to a lesser degree than with the COWAT. Although the best vacation task was not sensitive enough to detect age-related changes in spoken discourse production, the current findings seem to suggest that there is evidence of some underlying relationship between its quantitative properties and cognitive flexibility. Existing literature has yet to address this seemingly important relationship.

Another group of medium effect size correlations that did not reach statistical significance was with the best vacation percent of mazed words, which was correlated with the COWAT and RFFT. This indicates that participants with a higher percentage of mazed words tended to perform lower on the COWAT and the RFFT. A cognitive, rather than a linguistic explanation, would suggest that difficultly with word and utterance formulation is the outward result of decreased cognitive flexibility. Quite possibly, the decrease in cognitive flexibility interferes with the efficiency of spoken discourse production. Cognitive flexibility allows individuals to consider alternative responses and produce diverse ideas. In this study, the older adults, especially on the complex discourse elicitation task, self-corrected and reformulated utterances, creating the observed mazes.

In spoken discourse production, filled pauses or mazes appear to serve as markers of older adults attempting to use cognitive flexibility to devise or formulate responses. These audible online formulations and reformulations provided a window on which to observe a type of behavioral regulation through speech (Luria, 1973).

Cognitive flexibility measures and the complex discourse elicitation task variables had no significant correlations among them. However, a few nonsignificant correlations with medium effect sizes warrant attention. Specifically, the COWAT had positive correlations with the length of t-unit, which was a measure of efficiency, and with the amount of embedding and percent dependent clauses, which were measures of syntactic complexity. In addition, the COWAT also had a medium effect sized correlation with the Core Element score from the complex discourse elicitation task. The Core Element score gave insight into the typicality or richness of the discourse sample. Although not statistically significant, perhaps in a relatively more complex spoken discourse task, cognitive flexibility, as measured by the COWAT, is more important for efficiency and syntactical complexity. Moreover, cognitive flexibility may contribute to perceived richness and completeness of the discourse sample. Individuals who perform more poorly on the COWAT are more likely to be less efficient in imparting information and are more likely to use simple syntactical structures. Cognitive flexibility may have a role in providing information in a well-organized, concise manner. Cognitive flexibility may also subserve the maintenance of complex syntactical structures.

The general finding that there was a relationship between some variables measured in spoken discourse production and cognitive flexibility supports the findings of North, Ulatowska, Macaluso-Haynes, & Bell (1986). While not attempting to assess executive function specifically, the investigators found evidence indicating that older adults had reduced performance on cognitive as well as on discourse tasks. The participants were assessed using *Block Design, Raven's Coloured Progressive Matrices* (Part A and B), *Symbol-Digit*, and an unstandardized word fluency measure using the letter 's'. Both the *Raven's Coloured Progressive Matrices* (Part A and B), and the word fluency task are thought to be measures of executive function (Keil & Kaszniak, 2002; Lezak, 1995). The authors concluded that poorer discourse performance was related to an unspecified decrease in cognitive abilities in older adults (North et al., 1986). This decreased cognitive ability could be working memory in older adults and may account for the observed decrements in spoken discourse production (Caspari & Parkinson, 2000). However, a deficient central executive component may contribute to decreased working memory (Daneman & Carpenter, 1980).

AGE, COGNITIVE FLEXIBILITY, AND SPOKEN DISCOURSE PRODUCTION

The final question that this study investigated was: To what extent does age and cognitive flexibility influence performance on spoken discourse production tasks? To explore this question, a moderation model was attempted. The analysis was not completed because of failure to satisfy the precondition of significant predictors (see Table 11). The failure was due in part to the selected independent and dependent variables. While the dependent variable of complex discourse elicitation task percent of utterances with mazes distinguished age groups, it was not highly correlated with any of the cognitive flexibility measures. Likewise, the cognitive flexibility measures that most distinguished the age groups were not highly correlated with any of the spoken discourse measures. Furthermore, correlated spoken discourse variables and cognitive flexibility measures did not distinguish age groups. An additional analysis was completed to see if transforming the continuous variable of cognitive flexibility (COWAT) into a categorical variable clarified the results.

A MANOVA with the independent variables of age group (younger and older adults) and cognitive flexibility (high COWAT and low COWAT) was also completed. No significant main effects or interactions were found (see Table 12). Although this investigation did not support the hypothesis that the relationship between age and spoken discourse production differs at different levels of cognitive flexibility, this study still provided evidence that the interaction between age, spoken discourse production, and cognitive flexibility warrants further exploration. The lack of significant correlations may be due to a masking of some differences in age groups because this study did not use discrete age groups. A continuous series of age groups ranging from the late teens to the eighth decade were represented creating an overrepresentation of middle-aged participants. Middle-aged participants eclipsed large differences in spoken discourse between the youngest and the oldest groups of participants.

IMPLICATIONS AND FUTURE DIRECTION

This study was an attempt to draw connections where connections previously did not exist, namely between language and aging and cognitive flexibility, a component of executive function. Specifically, this study investigated cognitive flexibility as tested by linguistic and nonlinguistic fluency measures and spoken discourse production. A foundation has been established for further exploration of these relationships. In addition, this study contributed modest support for the executive decline hypothesis (Crawford et al., 2000; Dempster, 1992; Parkin & Walter, 1992), showing that older adults perform poorer on tests designed specifically to assess executive function (Bryan & Luszcz, 2000a; Raz et al., 1998). Moreover, this study provided some support for the speed of information processing hypothesis in that older adults scored lower than younger adults on the DSST. It is impossible to say whether poorer performance was due to reduced speed of information processing or due to declines in cognitive flexibility.

The current study provided additional normative data related to discourse performance across the adult life span. Secondly, it validated the two discourse elicitation tasks, the complex discourse elicitation task and the best vacation task. Evidence obtained suggests that as hypothesized in this study two tasks are fundamentally different in the cognitive demands imposed. Evidence indicates that the complex discourse elicitation task was sensitive enough to detect subtle age-related differences. That is, older adults performed qualitatively poorer than younger adults. In addition, the current investigation provided a protocol by which to test a component of executive function, cognitive flexibility that in turn improved the operationalization of executive function. The current study was unique in that it used a component of executive function as a means to clarify inconsistencies in the literature regarding age-related spoken discourse production.

An important consideration for a research investigation is whether the study will yield information that will advance theory. Theoretically, the results of the current investigation may contribute in that it highlights the dearth of information about the components of executive function as they relate to language. It provides an entry into this realm of study and a platform for launching future investigations. Several limitations in the current study should be considered. First, as with any study investigating cognitive processes, there was no direct observation of the constructs, but inferences were made about ability based measured performance. This study made a significant attempt to select assessments based on the underlying theoretical constructs and previous investigations of the instruments. Second, the population sample for this study may not be representative of gender, ethnicity, and educational background as distributed in society. The ability to generalize the results of the current study is thereby limited.

Furthermore, the lack of formal sensory and perceptual testing may have overlooked decrements in abilities that may have contributed to the age-related differences in found the current study. Finally, working memory was not formally assessed in this study. Spoken discourse production may have entailed other components of working memory not measured or accounted for in the current study.

Future studies of the affect of age and cognitive flexibility on spoken discourse production should include a representative sample in terms of gender, ethnicity, and socioeconomic background to increase generalizability of the results. A subjective listening measure by unfamiliar listeners would be useful in determining how mazes influence a listener's perception of spoken discourse. Other spoken discourse tasks need to be devised. Additional methods of increasing demands such as utilizing a more unusual event or perhaps describing steps in creating a nonsense object may be novel enough to help reveal more linguistic differences.

CONCLUSION

The current study did not reveal that age and cognitive flexibility interact to influence spoken discourse production. Nevertheless, the study does provide evidence to warrant the continued exploration of the relationship among age, cognitive flexibility, and spoken discourse production. This study also contributes to the growing body of literature in the area of spoken discourse production in normally aging adult populations. The findings of the current study indicate that overall, there is not a significant decrease in spoken discourse production with age, but on a relatively complex discourse production task older adults qualitatively differed from younger adults. Furthermore, findings of the present study indicated that cognitive flexibility, as measured by verbal and nonverbal fluency tasks, decreases with age. This seemingly parallel decrease in cognitive flexibility and changes in spoken discourse production with age still need further exploration. The study's information value lies in its potential to guide future studies of the influence of executive function on spoken discourse production. Continued study of executive function in various age, linguistic, and cognitive contexts will expand understanding of the construct. Because several researchers have found evidence that executive function does not exist as a unitary construct (Allain et al., 2001; Amieva et al., 2003; Baddeley, 2002; Della Sala et al., 1995; Hedden & Yoon, 2006; Miyake et al., 2000; Shallice, 2002; Sylvester et al., 2003) it is important to continue to investigate executive function in terms of its components. Investigating the components of executive function will address issues of specificity and sensitivity (Keil & Kaszniak, 2002; Stuss & Alexander, 2000; Wecker et al., 2000). Further exploration of cognitive flexibility and spoken discourse production can delineate what spoken discourse variables are the most vulnerable to decreases in cognitive flexibility due to age.

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Vita

Valarie Beavers Fleming was born in Little Rock, Arkansas on September 17, 1977, the daughter of Loretta Nickerson and Richard H. Beavers. After graduating with honors from North Pulaski High School in 1995, she began studies at The University of Central Arkansas in Conway, Arkansas. She graduated *magna cum laude* in May 1999 with the degree of Bachelor of Science in Speech Language Pathology with a minor in Honors College Interdisciplinary Studies. In August 1999, she entered the Graduate school of The University of Memphis, Memphis, Tennessee. She earned the degree of Master of Arts in Audiology and Speech Language Pathology in May 2001. During the following year, she was employed as a speech-language pathologist at ACCESS Schools in Little Rock, Arkansas. She was married to Delaney Fleming, Jr. on July 13, 2002. In August 2002, she received a fellowship from the Leadership Project in Multicultural Communication Sciences and Disorders to begin her doctoral studies at The University of Texas at Austin. She concurrently worked as a certified speech-language pathologist in the Seton Family of Hospitals in Austin, Texas. As a student at The University of Texas, she received the Jamail Endowed Presidential Scholarship. Her primary research focus is cognitive and linguistic aging in normal and disordered populations with a secondary interest in multicultural issues related to access and utilization of health services and information. Ms. Fleming holds the Certificate of Clinical Competence in Speech-Language Pathology (CCC-SLP) from the American Speech-Language-Hearing Association.

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